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ECONOMIC ASSESSMENT OF MUSTARD AND GROUNDNUT PRODUCTION IN SELECTED AREAS OF BANGLADESH

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Abstract

A study was conducted to perform the economic analysis of mustard and groundnut production in selected 90 mustard farmers from Rajshahi, Pabna, Sirajgonj districts and 35 groundnut farmers from Mymensingh district for interview. Forty nine percent of the total sampled areas were covered by mustard and 35.78% by groundnut of which 40 and 10.26 % were covered by HYV mustard and groundnut, respectively. The cost of HYV and local variety of mustard were Tk. 34060/ha and Tk. 28181/ha and net return of Tk. 27814/ha and Tk. 8914/ha. The cost of HYV and local variety of groundnut were Tk. 57749/ha and Tk. 43062/ha, respectively with net return of Tk. 21635/ha and Tk. 10116/ha. The benefit cost ratio of HYV mustard and groundnut were 1.82 and 1.37 over total cost basis and 2.63 and 1.98 over variable cost basis, respectively. Functional analysis showed that human labour, urea and TSP had significant impact on HYV mustard cultivation whereas human labour, TSP and gypsum was not significant for groundnut production. Scarcity of fertilizer was a major problem faced by the mustard and groundnut farmers in the study areas.

Introduction

Bangladesh is an agricultural country where different kinds of crops like cereals, pulses, oilseeds, vegetables and fruits are grown. Presently the requirement of country's edible oil is about 1.4 million metric tones of which a maximum of about 0.55 million metric tones is being supplied from the internal oilseeds production. This huge shortage is met through importing, which amount to about 76,729 million taka (Bakr, 2009). Groundnut contains vegetable oil (45-50%), protein (25-30%), carbohydrate (20%) and vitamin A and E (Ready & Kaul, 1986). It grows well in char land and yields are not much affected by changes in the sowing time. Its yield is much higher compared to other oilseed crops but not at satisfactory level (Farid, 2001). The yield (1491 kg/ha) of BARISarisha variety was developed by BARI showed higher than that of local variety (979 kg/ha). The areas under mustard and groundnut cultivation are 210526 ha and 33665 ha with the production of 189000 tons and 45910 tons, respectively (BBS, 2007).The maximum yield of groundnut was obtained by application of 30:26:33 kg NPK/ha in combination with gypsum application (Prasad, 2002). Sarker (2007) reported that the farmer received Tk.32539/ha and Tk.48131/ha as net return from sole mustard and mustard +garlic (intercrop), respectively.

Considering the ever-increasing demand of edible oils of the country, it is extremely needed to increase the total production of oilcrops by replacing the low yielding varieties by HYVs,

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improving management practices as well as increasing the area of cultivation where-ever possible. To minimize the yield gap between the farmer's field and research station trials, it is essential to undertake intensive research, extension and development activities (Wahhab *et. al* 2002). A number of indigenous low yielding oilseeds, traditionally cultivated in different parts of the country are highly susceptible to diseases and insect pests. Considering these factors, Bangladesh Agricultural Research Institute (BARI) have already developed 15 high yielding mustard varieties and 8 high yielding groundnut varieties along with recommended production packages. Attempts has been made to introduce HYV mustard/rapeseed and groundnut replacing the low yielding local varieties by motivating farmers through training, demonstration trials and publicities. For these purposes production of HYVs quality seed of mustard/rapeseed and groundnut should be ensured by involving different Government and non-government organizations in seed production and distributions. Hence, best possible way to increase production is to increase productivity by increasing efficiency. Considering its economic importance to achieve the sustainable mustard and groundnut production in Bangladesh, this study was under taken with the following objectives - to estimate the growth rate of mustard and groundnut cultivation in Bangladesh, to analyze the adoption level of mustard and groundnut cultivation, to assess the costs and returns of mustard and groundnut production, to analyze the interrelationship between inputs and outputs of mustard and groundnut cultivation and to identify the constraints of mustard and groundnut production.

Materials and Methods

Sampling design and data

The study was undertaken during 2007-2008 in four districts of Bangladesh, namely Rajshahi, Pabna, Sirajgonj and Mymensingh. In each district one upazilla and from each upazilla two villages were purposively selected on the basis of intensive mustard and groundnut growing area. A total of 90 sample farmers for mustard were selected randomly from Rajshahi, Pabna and Sirajgonj districts and 35 groundnut growers were also selected randomly from Mymensingh district. Data were collected with the help of a pre-designed and pre-tested interview schedule. The collected data were summarized and analyzed to fulfill the objectives set for the study. Tabular method of analysis using average, percentage, ratio etc. was done in this study.

Analytical Model

To estimation of growth rate time series data on area, production and yields of mustard and groundnut for 35 years from 1971/72 to 2005/06 were obtained from the website of the Ministry of Agriculture and different issues of the Statistical Yearbook of Bangladesh. The whole period (1972-2006) was divided into four periods viz, Period I (1972-1981), Period II (1982-1991), Period III (1992-2001), and period IV (2002-2006) to compare the rate of changes occurred in the area, production and yield of mustard and groundnut and explore the causes of changes.

The growth rates of area, production of mustard and groundnut were worked out by fitting a semi-log function of the following type:

$$y = e^{a+bt} \; or \; l_n y = a + bt$$

Where, y = Area (ha) or production (ton), t = Time period (year)

The production of mustard and groundnut is likely to be influenced by different factors. To determine the contribution of some important inputs of growing mustard and groundnut, the Cobb-Douglas production model was estimated because of the best fit of the sample data. The functional form of the Cobb-Douglas multiple regression equation was as follows.

$$Y = aX_1^{b1} X_2^{b2} \text{------------------} X_n^{bn} e^{ui}$$

For the purpose of the present empirical exercise the Cobb-Douglas production function was converted into the following logarithmic (Double log) form with variables:

$$LnY = Lna + b_1LnX_1 + b_2LnX_2 + \text{----------} + b_8LnX_8 + U_i$$

Where,

Y = Yield (kg/ha)
X_1 = Human Labour (man-day/ha)
X_2 = Ploughing cost (Tk/ha)
X_3 = Seed (kg/ha)
X_4 = Urea (kg/ha)
X_5 = TSP (kg/ha)
X_6 = MP (kg/ha)
X_7 = Gypsum (kg/ha)
X_8 = Irrigation and insecticide (Tk/ha)
b_1, b_2---------b_8 = Coefficient of the respective variable
U_i = Error term

Estimation of costs and benefits

The per hectare cost of mustard and groundnut cultivation was calculated by summing up all the costs incurred for various inputs. Gross return per hectare was calculated by summing up the value of output and its byproducts. The prevailing market prices of inputs and outputs were taken into consideration in this report. Net return was estimated by deducting gross cost from gross return.

Results and Discussion

Trend of area and production of mustard and groundnut in Bangladesh

Fig. 1 and 2 represent area and production under mustard and groundnut in Bangladesh. During the period of 1972 to 1983 the area under mustard cultivation was observed little fluctuation and increased upto 1986. After that the area under mustard decreasing than previous three years but it was much higher than initial year. During the period of 1988 to 2000 the area under mustard was more or less remain same. On the other hand, the area under groundnut cultivation was more or less same during the period of 1972 to 1987 and after that increased upto 2000. The area of mustard and groundnut cultivation was decreasing after 2000 (Fig. 1). Same trend was found in case of production of mustard and groundnut (Fig. 2). This may be due to competing with Boro and other rabi crops.

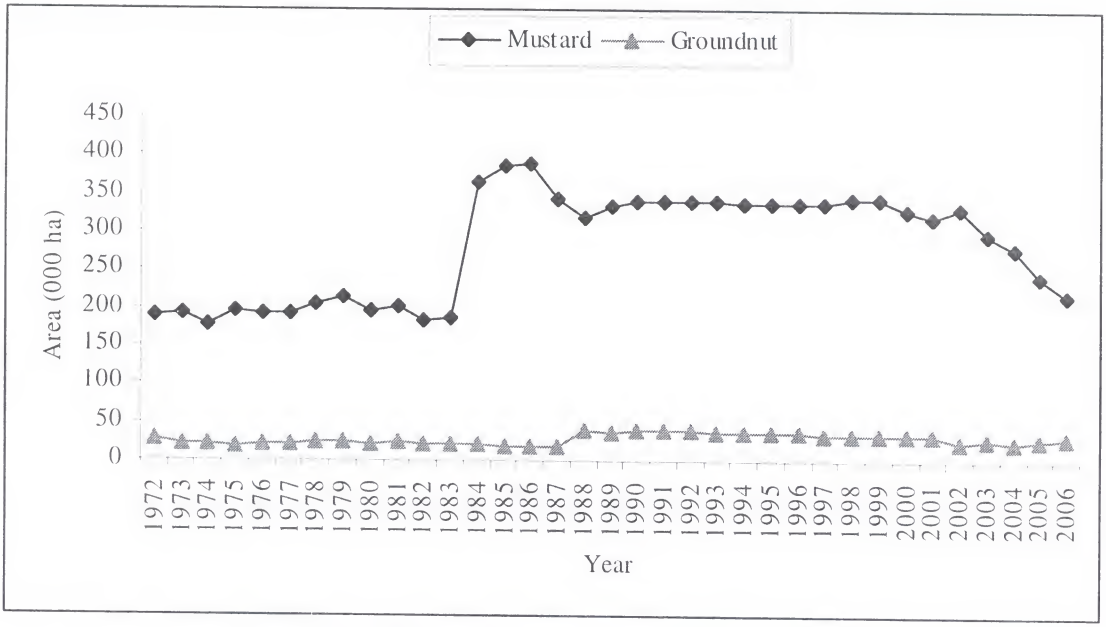

Fig. 1 Trend of area of mustard and groundnut production

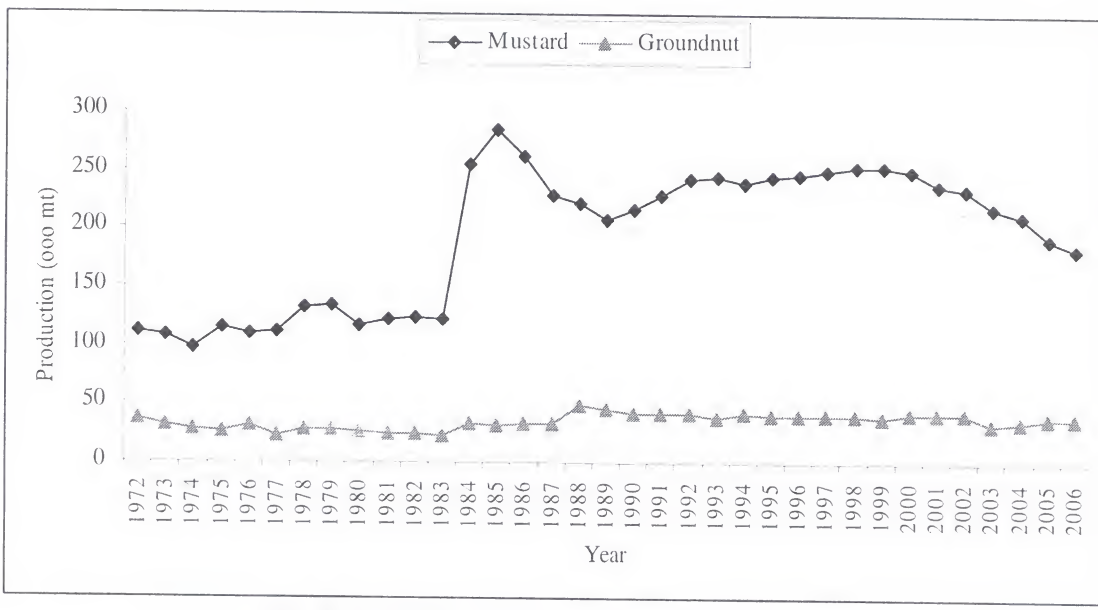

Fig. 2. Trend of production of mustard and groundnut

The area and production of mustard and groundnut registered positive growth rates over the period of 35 years (1972-2006). The overall growth rate of mustard production was found higher than that of groundnut. The growth rates of both the crops mustard and groundnut areas were negative but production rate of mustard and groundnut showed positive during 1992-2001 (Table 1).

Table 1. Growth rates of area and production of mustard and groundnut during 1972-2006

Year	Mustard	Groundnut
	Area	
1972-1981	0.011	0.003
1982-1991	0.052	0.091
1992-2001	-0.004	0.014
2002-2006	-0.105	0.033
1972-2006	0.016	0.014
	Production	
1972-1981	0.020	-0.028
1982-1991	0.046	0.071
1992-2001	0.002	0.0007
2002-2006	-0.061	-0.007
1972-2006	0.025	0.013

Area covered by mustard and groundnut cultivation

In the study areas, 48.78% area covered by mustard in respect with total cultivated sampled areas. Out of this area, 40% covered by HYV mustard and rest by local variety (Table 2 and 3). On the other hand, 35.78% area covered by groundnut in respect with total cultivated sampled areas. Out of which, 10.26% area covered by HYV groundnut and rest by local variety (Table 4 and 5).

Table 2. Average area covered by mustard in the sampled farmer

Locations	Total land (ha/farmer)	Cultivated land (ha/farmer)	Land under mustard cultivation	% in respect with cultivated land
Rajshahi	1.24	1.18	0.46	38.98
Pabna	0.66	0.58	0.29	50
Sirajgonj	0.64	0.71	0.46	64.79
All	0.85	0.82	0.40	48.78

Table 3. Average area covered by HYV and local mustard cultivation in the sampled farmer

Locations	HYV (ha)		Local (ha)	
	Total (ha/farmer)	% in respect with mustard cultivated areas	Total (ha/farmer)	% in respect with mustard cultivated areas
Rajshahi	0.18	39.13	0.28	60.87
Pabna	0.12	41.38	0.17	58.62
Sirajgonj	0.19	41.30	0.27	58.70
All	0.16	40.00	0.24	60.00

Table 4. Average area covered by groundnut in the sampled farmers

Locations	Total land (ha/farmer)	Cultivated land (ha/farmer)	Land under groundnut cultivation	% in respect with cultivated land
Mymensingh	1.26	1.09	0.39	35.78

Table 5. Average area covered by HYV and local groundnut cultivation in the sampled farmers

Locations	Total (ha/farmer)	% in respect with groundnut cultivated areas (HYV) (ha)	Total (ha/farmer)	% in respect with groundnut cultivated areas (local) (ha)
Mymensingh	0.04	10.26	0.35	89.74

Pattern of Input Use

Human labour was mainly employed in land preparation, seed sowing, fertilizer, insecticides, weeding, harvesting and threshing. Table 6 and Table 7 shows that 95 man-days and 140 man-days of human labour were required per hectare in cultivating HYV mustard and groundnut, 73 man-days and 102 man-days for local varieties. The farmers of Rajshahi used more labour for HYV mustard cultivation than that of Pabna and Sirajgonj. On an average, seed rate was used 7.66 and 110.61 kg/ha for HYV mustard and groundnut, respectively, whereas it was 8.02 and 124.75 kg/ha for local varieties. Per hectare fertilizer (urea, TSP, MP and gypsum)

Table 6. Pattern of labour and input use for the cultivation of mustard in sampled area

Labour and Inputs used	Location							
	Local Variety				HYV			
	Raj-shahi	Pabna	Siraj-ganj	All	Raj-shahi	Pabna	Siraj-ganj	All
H. labour (m-d/ha)	78	71	70	73	100	94	90	95
Hired labour	51	42	48	47	67	56	62	62
Family labour	27	29	22	26	33	38	28	33
Seed (kg/ha)	7.52	7.93	8.61	8.02	7.44	7.79	7.74	7.66
Urea (kg/ha)	119.82	144.82	176.20	146.95	173.25	153.74	207.33	178.11
TSP (kg/ha)	34.31	103.26	108.31	81.96	141.16	126.24	146.69	138.03
MP (kg/ha)	34.02	54.00	47.26	45.09	64.54	73.31	73.88	70.58
DAP (kg/ha)	33.64	---	48.78	27.47	3.74	--	--	1.25
Gypsum (kg/ha)	20.16	70.83	48.39	46.46	125.93	117.77	111.69	118.46
Borax (kg/ha)	1.18	1.0	1.26	1.15	3.97	4.53	1.97	3.49
ZnO (kg/ha)	---	0.72	--	0.24	--	3.74	---	1.25
Cow-dung (kg/ha)	495.98	971.97	1824.75	1097.5	505.23	187.69	1567.08	753.33

Table 7. Pattern of labour and input use for the cultivation of groundnut in sampled area

Labour and Inputs used	Mymensingh	
	Local Variety	HYV
Human labour (m-d/ha)	102	140
Hired labour (m-d/ha)	59	71
Family labour (m-d/ha)	43	69
Seed (kg/ha)	124.75	110.61
Urea (kg/ha)	1.74	19.31
TSP (kg/ha)	17.48	109.70
MP (kg/ha)	11.39	42.14
Gypsum (kg/ha)	31.73	245.5
Borax (kg/ha)	0.37	5.45

used were 178.11, 138.03, 70.58 and 118.46 kg, respectively for HYV mustard and 146.95, 81.96, 45.09 and 46.46 kg for local variety. Per hectare fertilizers(urea, TSP, MP and gypsum) used were 19.31, 109.70, 42.14 and 245.5 kg for HYV groundnut and it was 1.74, 17.48, 11.39 and 31.73 kg for local variety, respectively.

Cost of Production

The cost of production included all variable cost items like human labour, animal power, power tiller, seed, manures, fertilizers, insecticides, irrigation etc. Both cash expenditure and imputed value of family owned inputs have been included. In case of family supplied inputs, opportunity cost was considered. On an average per hectare cost of HYV mustard was Tk. 34060 and local variety was Tk. 28181 whereas Tk. 57749 and Tk. 43062 for local variety of groundnut (Table 8 & 9). The cost of production was higher in groundnut cultivation compared to mustard due to higher labour and seed cost.

Table 8. Per hectare cost and return of mustard cultivation in the study areas

Items	Locations							
	Local Variety				HYV			
	Rajshahi	Pabna	Sirajganj	All	Rajshahi	Pabna	Sirajganj	All
A. Variable Cost (VC)								
Hired labour	6768	5695	6324	6263	8680	7747	8020	8149
Seed	463	493	560	505	510	514	555	526
Urea	831	1065	1199	1032	1154	1037	1420	1204
TSP	854	2425	3067	2116	3510	2975	4150	3545
MP	802	1367	1327	1165	1497	1825	2066	1796
Zipsum	78	450	297	275	474	118	689	427
ZnO	--	50	--	17	--	291	--	97
DAP	1316	--	1864	1060	142	--	--	47
Borax	216	89	373	226	748	377	573	566
Cowdung	496	972	1825	1098	505	188	1567	753
Ploughing cost	2453	2312	2389	2385	2382	2321	2457	2387
Insect/Pesticide	234	172	33	146	743	775	561	693
Irrigation cost	395	138	80	205	446	763	654	621
Transportation	1932	1119	1836	1629	3115	807	2784	2235
Int. on opp. capital	337	327	423	362	478	395	510	461
TVC	17174	16675	21596	18482	24384	20132	26007	23508
B. Fixed Cost (FC)								
Family labour	3581	4014	2866	3487	4260	5330	3606	4399
Rental value of land	5464	8233	4940	6212	5439	7998	5023	6153
TFC	9045	12247	7806	9699	9699	13329	8629	10552
C. Total Cost (A+B)	26219	28922	29402	28181	34083	33460	34636	34060
Yield (kg/ha)	794	762	770	775	1323	1197	1220	1247
Return from mustard	34743	35695	34736	35058	61171	56363	61146	59560
Return from straw	2087	1991	2035	2037	2345	2377	2221	2314
D. Total return	36829	37686	36771	37095	63515	58739	63367	61874
Net return								
Over VC	19655	21011	15175	18613	39131	38607	37360	38366
Over TC	10610	8764	7369	8914	29432	25279	28731	27814
Benefit cost ratio:								
Over VC	2.14	2.26	1.70	2.01	2.60	2.92	2.44	2.63
Over TC	1.40	1.30	1.25	1.32	1.86	1.76	1.83	1.82

Profitability of mustard and groundnut production

The average yield was 1247 kg/ha for HYV mustard and 775 kg/ha for local variety of mustard. In this study, gross returns were Tk. 61874/ha and Tk 37095/ha for HYV and local variety of mustard, respectively. The farmer received Tk. 27814/ha and Tk 8914/ha as net returns for HYV and local variety of mustard. The benefit cost ratios (BCR) from HYV mustard

was calculated as 1.82 on total cost basis implying that one taka investment in HYV mustard return would generate Tk. 1.82 (Table 8).

The average yield was 2238 and 1540 kg/ha for HYV and local variety of groundnut, respectively. The gross returns were Tk 79384/ha and Tk 53178/ha for HYV and local variety of groundnut whereas farmers received Tk 21635/ha and Tk 10116/ha as net return. The benefit cost ratios (BCR) from HYV groundnut was calculated as 1.37 on total cost basis implying that one taka investment in HYV groundnut return would generate Tk 1.37 (Table 9). Benefit cost ratio in all the cases were higher then one. So, both the crops appeared to be economically profitable.

Table 9. Per hectare cost and return of groundnut cultivation in the study area

Items	Mymensingh	
	Local Variety	HYV
A. Variable Cost (VC)		
Hired human labour	7564.92	10567.11
Seed	17235.68	17033.57
Urea	12.00	144.61
TSP	519.38	2713.02
MP	332.41	1219.43
Gypsum	195.28	1512.54
Borax	47.51	678.73
Ploughing cost	2389.59	2642.15
Insecticide/Pesticide	---	990.99
Transportation cost	543.78	1101.77
Interest on operating capital	1153.62	1544.16
Total Variable Cost (TVC)	29994.17	40148.08
B. Fixed Cost (FC)		
Opportunity cost of family labour	5459.63	10238.82
Rental value of land	7607.06	7360.60
Total Fixed Cost	13066.69	17599.42
C. Total Cost (A+B)	43060.86	57747.5
Nut yield (kg)	1540.16	2237.52
Gross return (Tk./ha)	53178.34	79375.32
Net return (Tk/ha)		
Over variable cost	23184.17	39227.24
Over total cost	10117.48	21627.82
Benefit cost ratio		
Over variable cost	1.77	1.98
Over total cost	1.23	1.37

A. Variable cost included all input cost except cost of family labour
B. Fixed cost included opportunity cost of family labour and land cost

Input output relationship

Estimated values of coefficient and related statistics of Cobb-Douglas production function of mustard and groundnut are presented in Table 10 and Table 11. The result showed that most of the coefficients had positive sign. The coefficient of human labour (X_1) was found positive and significant in both varieties of mustard and groundnut at 1 % level of significance. It indicates that 1 % increase human labour for better practice and management with other factors remaining constant would increase the production of HYV mustard, local variety of mustard and groundnut by 0.39, 0.44 and 0.446, respectively. The coefficient of TSP(X_5) also found to be positive and significant in all cases. Coefficient of ploughing cost(X_2) is found positive and

significant for local variety of mustard and groundnut while it was negative for HYV mustard. The coefficient of seed (X_3) and gypsum(X_7) for local variety of mustard and coefficient of MP (X_6) for groundnut were found negative and significant which indicate inefficient use of these inputs for crop production. The coefficient of multiple determinations (R^2) was found 0.69, 0.61 and 0.84 for HYV mustard, local variety of mustard and groundnut, respectively implying that the explanatory variables included in the model explained 69%, 61% and 84 % of the variation in return from these crops production. The F-value of all the equation were found significant at 1% level indicating that the variation in return from these crops mainly depends upon the explanatory variables included in the models.

Table 10. Estimated values of coefficients and related statistics of Cobb-Douglas Production function model for mustard

Explanatory variable	HYV		Local	
	Coefficient	t-values	Coefficient	t-value
Intercept	6.929	5.224	-0.886	-0.419
Human labour (X_1)	0.399*** (0.103)	3.882	0.435*** (0.147)	2.950
Ploughing cost (X_2)	-0.561*** (0.185)	-3.034	0.744*** (0.270)	2.756
Seed (X_3)	0.244 (0.189)	1.291	-0.296* (0.160)	-1.846
Urea (X_4)	0.166* (0.086)	1.925	0.101 (0.100)	1.001
TSP (X_5)	0.235** (0.112)	2.092	0.004*** (0.015)	3.227
MP (X_6)	0.003 (0.073)	0.549	0.007 (0.016)	0.463
Gypsum (X_7)	0.003 (0.055)	0.637	-0.003*** (0.014)	-2.725
Irrigation and insecticide (X_8)	-0.002*** (0.005)		-0.0009 (0.009)	-1.093
R^2	0.689		0.606	
F	5.821***		6.147***	

Figures in the brackets are standard errors of the regression coefficient
***Significant at 1% level, ** Significant at 5% level, *Significant at 10% level

Table 11. Estimated values of coefficients and related statistics of Cobb-Douglas Production function model for groundnut

Explanatory variable	Coefficient	t-value
Intercept	1.772	0.803
Human labour (X_1)	0.446*** (0.142)	3.148
Ploughing cost (X_2)	0.266* (0.155)	1.719
Seed (X_3)	0.286 (0.281)	1.019
Urea (X_4)	-0.047 (0.049)	-0.968
TSP (X_5)	0.527** (0.250)	2.108
MP (X_6)	-0.703*** (0.194)	-3.619
Gypsum (X_7)	0.215* (0.123)	1.745
Borax (X_8)	0.003 (0.082)	0.373
R^2	0.836	
F	14.029***	

Figures in the brackets are standard errors of the regression coefficient
***Significant at 1% level, ** Significant at 5% level, *Significant at 10% level

Constraints of mustard and groundnut cultivation

The sample farmers encountered different constraints in cultivation of mustard and groundnut. The major constraints were found to be scarcity of fertilizer (96%), timely non-availability of good seed (78%), HYV seeds are not available in the market (70%), timely not available human labour (58%) and incidence of disease (25%). Farmers opined that they could not attain expected yield due to these constraints (Table 12).

Table 12. Constraints to mustard and groundnut cultivation

Constraints	Mustard			Groundnut	All areas
	Rajshahi	Pabna	Sirajganj	Mymensingh	
Scarcity of fertilizer	29 (96.57)	30 (100)	28 (93.24)	33 (94.28)	120 (96)
Timely non- availability of good seed	23 (76.59)	24 (79.92)	24 (79.92)	26 (74.24)	97 (77.6)
HYV seeds are not available in the market	21 (69.91)	21 (69.91)	19 (63.27)	26 (74.24)	87 (69.6)
Timely not available human labour	18 (59.94)	15 (49.95)	17 (56.61)	22 (62.86)	72 (57.6)
Incidence of disease	9 (29.97)	8 (26.64)	6 (20)	8 (22.85)	31 (24.8)

Note: Figures in the brackets indicate percentage

Conclusion and Recommendations

Based on the result it can be concluded that the average yield of HYV mustard and groundnut is higher than local variety. This crop is gaining popularity in the country very quickly due to its high yield potential. Optimum level of input use and timely by cultural operation is important for achieving higher yield and profits. Although HYV mustard and groundnut is a profitable crop but it is very cash cost crop thereby high cash involvement may restrict mustard and groundnut area expansion. A good opinion came out from the sample farmers that higher yield and income encourage them for continuing mustard and groundnut cultivation. They also revealed that most of the coefficient had significant impact on the yield of mustard and groundnut. To increase the production, information like proper sowing time, seed rate, fertilizer dose needs to be provided to the farmers and strong extension programme and proper monitoring by the field staff need to ensure to increase area under mustard and groundnut production. Credit should be supplied to the poor farmers with low interest and easy terms. It is extremely needed to increase the total production of oilcrops by fitting the oilcrops in existing cropping patterns, replacing the low yielding varieties by HYVs, improving management practices by motivating farmers through training, demonstration trials and publicities.

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CONCURRENT CULTURE OF SHRIMP AND TILAPIA IN THE COASTAL POND

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Abstract

An on-farm study with the active participation of farmer was conducted in and around Paikgacha, Khulna to validate the technique of production of shrimp (*Penaeus monodon*) and genetically improved farmed tilapia (GIFT) in concurrent culture system in the brackish water ponds. The grow-out ponds were stocked with shrimp @ $2/m^2$ and GIFT @ $1/m^2$ standardized for concurrent culture in the on-station study. After 65~76 days of culture, shrimps of two ponds were attacked with white spot viral disease. In the other pond, production of shrimp was 339.29 kg/ha and that of GIFT was 1777.02 kg/ha after 120 days of rearing. Cost of production in this pond was Tk. 1,35,346.00/ha with the cost benefit ratio of 1.00:2.38. Production of shrimp and GIFT in ponds with viral attack was 92.47~135.70 kg/ha and 1726.48~1782.00 kg/ha, respectively. Gross return from GIFT was higher than total cost of production in all ponds indicating that farmers will not loose investment for production in case of mass mortality of shrimp due to outbreak of viral disease. Extension of this production process with wider-scale would increase production of both shrimp and fish.

Introduction

The importance of shrimp (*Penaeus monodon*) in the development of national economy of Bangladesh is worth mentioning. Shrimp is the second largest export earning commodity of the country. But due to outbreak of white spot viral disease in 1994, the whole sequence of development of shrimp culture system has been disrupted seriously. The disease has threatened the whole shrimp culture industry in Bangladesh. As a result, the marginal farmers have lost their interest in shrimp culture. No technology has yet been developed worldwide for controlling viral disease in shrimp. Bangladesh Fisheries Research Institute (BFRI) developed culture technology of shrimp with the provision of prevention of viral disease (Saha and Alam, 2008). But this technology is not affordable by the marginal and medium scale farmers as it involves large amount of investment. To minimize the risk of loosing investment in case of mortality of shrimp due to invasion of virus in coastal shrimp farms and to develop a production technology suitable for the small and medium scale farmers, Bangladesh Fisheries Research Institute (BFRI) conducted several studies on the diversification of crops in coastal shrimp farms with different species combinations and densities of fishes (Ali *et al.* 2000; Shofiquzzoha *et al.* 2001; Anon, 2006 and 2007). Recently Alam *et al.* (2008) reported that tilapia did not exert any significant effect on the water quality and survival of shrimp in rice-shrimp rotational system. Considering availability of seed, ecological advantage and economics, the above studies indicated that genetically improved farmed tilapia (GIFT) strain of Nile tilapia (*Oreochromis niloticus*) would be the most suitable of all available salt tolerant species (e.g., Grey mullet, *Barbonymus gonionutus* and *Pangasianodon hypophthalmus*) which could be reared with *P. monodon* in brackishwater ponds. The Nile tilapia could survive and grow in poor water quality with low dissolved oxygen level (Anon, 1998). Green (1997) reported that the Nile tilapia can tolerate salinity as high as 3.6 to 4.0%, but best growth occurs at salinity below 2.0%. Hussain

(2004) suggested that commercial farming of tilapia could be an alternative in brackishwater ponds where shrimp culture collapse due to disease outbreak.

The ecological and economic aspects of shrimp-tilapia culture were being studied by different workers (Fitzsimmons, 2001; Jin *et al.* 2001; Joseph *et al.* 2001; Cruz *et al.* 2008) in different countries. They recommended that tilapia-shrimp polyculture practice would be technically feasible, economically attractive and environment friendly, if the initial capital would be affordable for the small scale farmers. Recently, BFRI standardized the stocking density of shrimp with GIFT in concurrent culture system and recommended that shrimp with more than $2/m^2$ density will not be feasible at extensive culture system (Saha *et al.* 2009). Before recommendation for wider extension, an on-farm trial with the active participation of farmers was conducted to validate the culture technique at the farmers' level.

Materials and Methods

The study was conducted in three ponds of two shrimp farms in and around Paikgacha, Khulna in 2009. The particulars of the ponds are given in Table 1. The grow-out ponds were stocked with shrimp @ $2/m^2$ and GIFT, @ $1/m^2$ after nursing as recommended for concurrent culture in the on-station studies. For nursing of post larvae (PL) of shrimp and fry of GIFT, two separate in-pond nurseries, each covering an area of 4~5% of the pond, were prepared by encircling with nylon net fastened in bamboo frame in every pond.

After drying, soil of the ponds were treated with lime (CaO) @ 250 kg/ha. Then the ponds of both farms were fed with the tidal water of a tributary of Shibsa river up to a depth of 83~100 cm. Animalcule of water was killed by applying rotenone and then dipterex @ 1.50 ppm each. Water of the ponds was then treated with dolomite @ 20 ppm and after three days, fertilized with urea @ 2.5 ppm and TSP @ 3.0 ppm. After production of sufficient plankton, required quantity of PL of shrimp (PL20) and fry of GIFT (2.65 ± 0.15g) were stocked in the in-pond nurseries of pond # 1 on 18th March' 2009 and pond # 2 & 3 on 11th March' 2009. The area of ponds were 2000, 1308 and 1180 m^2 of ponds 1,2 and 3, respectively. After two weeks, juveniles of shrimp and GIFT were allowed to spread throughout the culture pond by opening the nursery enclosure. Shrimps were fed with commercial pellet feed (Saudi-Bangla shrimp feed) and fishes with locally formulated feed (approx. 35% protein content, consisting of a mixture of fishmeal-29%, sesame oil cake-15%, rice bran-35% and soybean meal-21%) twice daily following the technique as mentioned by Saha *et al.* (2009). After stocking, water of the ponds was treated monthly with dolomite @ 15.0 ppm and fertilized with urea @ 1.2 ppm and TSP @ 1.5 ppm. To maintain undisturbed ecology of the ponds, no water was exchanged. Only the evaporated water was replenished by tidal water after screening. Water quality parameters *viz.,* depth, temperature, salinity, pH, transparency and alkalinity were monitored at fortnightly interval. But dissolved oxygen was monitored frequently. The water quality variables were determined following standard methods as mentioned by APHA (1992). Growth of shrimp and GIFT was monitored fortnightly. Shrimps in pond # 2 and 3 were attacked with viral disease after 76 and 65 days of culture and a few dead shrimp was observed at the periphery of the ponds. At this situation, shrimp from these ponds were harvested by netting. Shrimp from pond # 1 and GIFT from all ponds were harvested after 120 days of rearing by netting followed by dewatering ponds. Growth and production were then estimated.

Results and Discussion

The recorded water quality variables are shown in Table 2 and variations of some variables are depicted in Fig 1. Variations of different water quality parameters except depth among different ponds were not remarkable. Depth of water of pond # 1 was higher (95~100 cm) in comparison to pond # 2 (75~83 cm) and pond # 3 (72~85 cm). As shown in Fig. 1a, initially transparency of water of the ponds was 32~37 cm, which increased after stocking to some extent and then gradually decreased to lowest level of 26.0~28.0 cm at the end of the culture period indicating increase in plankton production. The variation in salinity of all ponds was almost same and ranged from 8 to 16 ppt. Salinity of water was lowest during stocking and then gradually increased up to 75 days of culture. Then salinity began to decrease (Fig. 1b) with the onset of monsoon precipitation. Temperature of water of the ponds was almost same and varied from 29.5 to 34.0°C. pH of water of all ponds was always alkaline and ranged from 8.00 to 8.82. As shown in Fig. 1c, variation in concentration of dissolved oxygen among different ponds was not remarkable and the average concentration was 3.62-7.34 mg/l. The concentration of dissolved oxygen was initially higher and then began to decrease with the progress of culture period. As indicated in Fig. 1d, total alkalinity level of water of the ponds was always congenial for the culture of shrimp and fish and varied from 98.45 to 129.34 mg/l.

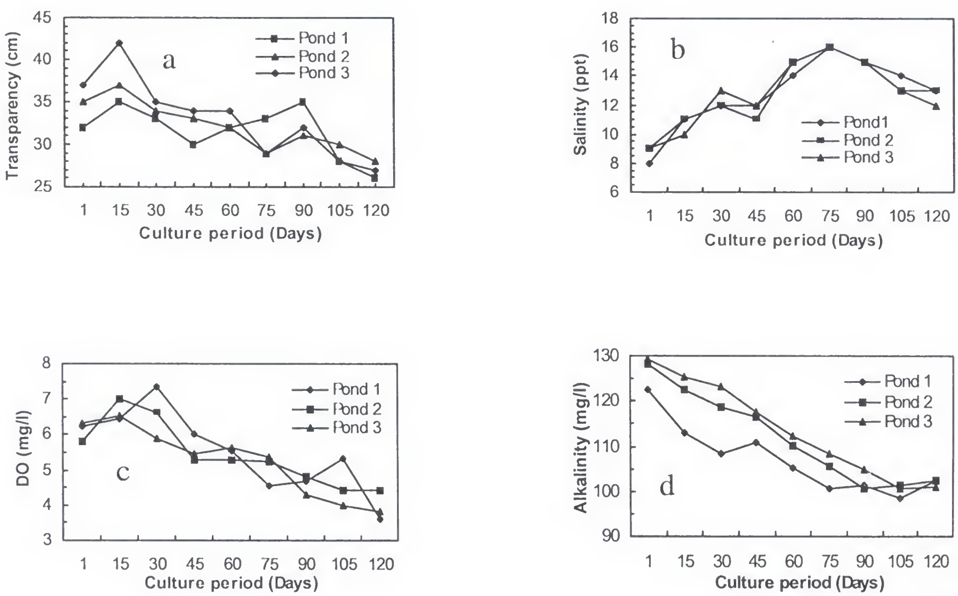

Fig. 1. Variations in some water quality variables of ponds used for concurrent culture of shrimp (*Penaeus monodon*) with genetically improved farmed tilapia (GIFT).

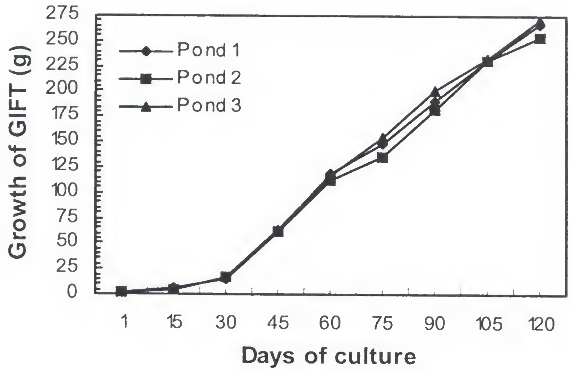

Fig. 2. Growth of genetically improved farmed tilapia (GIFT) in concurrent culture system with shrimp (*Penaeus monodon*) in the brackishwater ponds

As the growth of shrimp is concerned, it was observed that after 65 to 76 days of culture, shrimp attained an average wt. of 23.56 g, 17.46 g and 15.32 g in pond # 1, 2 and 3, respectively. The later two ponds were attacked with viral disease but no viral invasion was observed in pond # 1. After 120 days of culture, production of shrimp in pond # 1 was 339.26 kg/ha with average wt. of 23.56 g and survival of 72% (Table).

As could be seen from Fig. 2, fry of GIFT, which measured 2.65±0.15 g at the time of stocking, reached an average weight of 266.82 ± 6.72 g, 253.15 ± 5.34 g and 270.00 ± 7.74 g after 120 days of culture in pond # 1, 2 and 3, respectively, indicating no significant difference in growth of GIFT among three ponds. On the other hand, survival of GIFT was 66.60, 68.20 and 66.00% and production was 1777.02, 1726.48 and 1782.00 kg/ha in pond # 1, 2 and 3, respectively with an average production of 1761.83 kg/ha. The feed conversion ratio (FCR) of concurrent culture of shrimp with GIFT varied from 1.83, 1.72 and 1.75 in pond # 1, 2 & 3, respectively (Table 1).

Expenditure and income from concurrent culture of shrimp and GIFT are shown in Table 2. Cost of production included all variable and fixed costs needed for the culture practice and bank interest. Total cost of production in pond # 1 was highest of Tk. 1,35,346.00/ha where shrimps were not invaded with virus but lower in pond # 2 (Tk.1, 14,262.00/ha) and pond # 3 (Tk.1,12,560.00/ha), where shrimps were attacked with viral disease. The untimely earlier harvest of shrimp due to outbreak of white spot viral disease drastically reduced the production of shrimp in pond # 2 & 3. But production of GIFT in these ponds was almost same or higher than that of pond # 1. This high cost of production in pond # 1 was due to the extra cost of feed needed to rear shrimp up to 120 days. Total gross income (Tk. /ha) was highest of 3,22,291.10 in pond # 1, followed by 2,06,991.05 in pond # 3 and 2,01,823.50 in pond # 2. Similar trend was followe where net return (Tk./ha) was 1,86,945.10, 87,561.50 and 94,431.05 with the cost benefit ratio (BCR) of 2.38, 1.77 and 1.83 in pond # 1, 2 & 3, respectively. The highest gross return from pond # 1 was due to highest production and market price of shrimp in comparison to other ponds. Saha *et al.* (2009) also reported a production of 289.43 kg/ha shrimp and 1457.04 kg/ha GIFT with the net return of Tk.1,22,145.00 /ha in concurrent culture of shrimp @ 2 m^2 density and GIFT @1 m^2 density in the on-station ponds.

Table 1. Poduction performance of shrimp (*Penaeus monodon*) and GIFT in concurrent culture system in the brackish water ponds

Ponds	Species	Initial weight (g)	Growth 65-75 days of culture (g)	Survival (%)	Production (kg/ha)	** FCR
1	Shrimp	0.006	23.56	72.00	339.26	1.83
	GIFT	2.65	266.82	66.60	1777.02	
2	Shrimp	0.006	17.46	38.86	135.70	1.72
	GIFT	2.65	253.15	68.20	1726.48	
3	Shrimp	0.006	15.32	30.18	92.47	1.75
	GIFT	2.65	270.00	66.00	1782.00	

* Shrimp attacked with viral disease after 65~76 days culture
** FCR, feed conversion ratio

Table 2. Expenditure and income from concurrent culture of shrimp (*Penaeus monodon*) with genetically improved farmed tilapia (GIFT)

Ponds	Species	Total cost* (Tk./ha)	Gross return (Tk./ha)	Net return (Tk./ha)	**BCR
1	Shrimp	1,35,346.00	S = 135704.00 F =186587.10	1,86,945.10	2.38
	GIFT		Total = 3,22,291.10		
2	Shrimp	1,14,262.00	S = 29175.50 F =172648.00	87,561.50	1.77
	GIFT		Total = 2,01,823.50		
3	Shrimp	1,12,560.00	S =19881.05 F =187100.00	94,431.05	1.83
	GIFT		Total= 2,06,991.05		

* Cost of land lease, embankment repair, piscicide, shrimp & fish seed, feed, fertilizer, lime, bamboo, labour, nylon net, minor tools, harvest and bank interest.
** Benefit-Cost Ratio (S= Shrimp; F= GIFT). Pirce: Shrimp, Tk.400/kg, GIFT, Tk. 215/kg

However, the cost benefit analysis indicates that gross return from sale of GIFT over total gross return was 85.54, 91.01 and 57.89 % in pond # 1, 2 & 3, respectively, which were higher than the total production cost. The result indicated that even after total mortality of shrimp caused by viral infection, farmers would not loose the investment if GIFT would be stocked with shrimp as also reported by Saha *et al.* (2009). If there be no outbreak of disease in shrimp, the cost benefit ratio would be higher than that of 1.88 as reported by Saha *et al.* (2006-07) in semi-intensive culture of shrimp, where production of shrimp was about 1700 kg/ha and cost of production was more than taka five lakhs/ha. An earlier study also indicated that addition of tilapia would not significantly affect the production of shrimp in concurrent culture system (Anon, 2007). Moreover, net return from shrimp-tilapia concurrent culture system was higher than that of monoculture of shrimp at the same stocking density. Akiyama and Anggawati (1999) reported that yields of shrimp increased when tilapia were stocked into shrimp ponds. They also mentioned that tilapia assist shrimp performance by improving and stabilizing the

water quality, by foraging and cleaning the pond bottom, and by having a probiotic type of effect in pond environment. In extensive system very less preventive measures are taken to prevent viral disease in pond, so there is risk of mass mortality of shrimp due to outbreak of disease. So, monoculture of shrimp in extensive system will no way assure a profitable harvest but there is every possibility of loosing investment by the mass mortality, which may discourage farmers for future stocking of shrimp into the pond.

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EFFECT OF GROWTH REGULATORS ON PLANT EMERGENCE, GROWTH AND FLOWER PRODUCTION OF GLADIOLUS

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Abstract

Effects of growth regulators on plant emergence, growth and flower production of gladiolus were studied at Bangladesh Agricultural University, Mymensingh during November 2007 to April 2008 under a replicated field trial. Three doses of gibberellic acid (GA_3) viz. 50 ppm, 100 ppm, 200 ppm and Paclobutrazol (PP333) viz. 20 ppm, 40 ppm and 80 ppm including control treatments were tested. It was found that GA_3 showed better performance than the PP333, GA_3 at 200 ppm showed the best result in yield contributing characters such as reducing the number of days for 80% emergence, first spike initiation, 80% spike initiation, 80% harvest and increasing the number of tiller per hill, total number of spike per hill, length of spike and rachis, number of florets per spike and shelf-life of flower production of gladiolus.

Introduction

Gladiolus (*Gladiolus grandiflorus* L.), is a popular cut flower usually known as Sword Lily. It is a monocot ornamental bulbous plant native of South Africa (Sharma and Sharma, 1984) under Iridaceae family. It is estimated that more than 2,500 hectare of land is under gladiolus cultivation in Bangladesh (Dadlani, 2003).

Plant growth and development are regulated by naturally produced chemicals or endogenous plant hormones. The potential use of growth regulators in flower production has created considerable scientific gain in recent years. Auge (1982) observed early growth and flowering in gladiolus cv. Sylvia when corms were kept in GA_3 solutions for 24 hours. Corms treated with GA_3 enhanced plant growth and flowering in gladiolus in India (Bhattacharjee, 1984). Dua *et al.* (1984) observed improved flower quality and better corm multiplication when corms of gladiolus were soaked in 100 ppm GA_3 before planting. EL-Meligy (1982) observed higher anthocyanin accumulation in flowers resulting deeper flower colour when treated with GA_3 500 ppm. Nilimesh and Roychowdhury (1989) treated gladiolus corms (2.5- 2.7 cm in diameter) by soaking for 6 hours in GA_3 (50 or 100 ppm) irrespective of concentration increased plant height, flower stalk length and yield of corms per unit area and decreased the days required to 50% inflorescence initiation and percentage of lodging plant. In a separate investigation, Mahesh and Misra (1993) studied the effect of gibberellic acid (200, 500 and 1000 ppm) on gladiolus cv. Snow Princess where significant changes in growth and flowering

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were obtained for many parameters. GA_3 at 200 ppm increased the plant height from 87.39 to 91.94 cm but the GA_3 at 1000 ppm increased the number of florets/spike from 10.19 to 10.67. Use of GA_3 at 0, 50, 100, 200, or 400 ppm on gladiolus corm *cv.* Sylvia at Kanpur, India enhanced vegetative growth, flowering and number of corm and cormel production, but adversely affected individual corm weight while higher doses (200 and 400 ppm) reduced the duration of flowering (Misra *et al.* 1993). Karaguzel *et al.* (1999) reported that GA_3 at 100 ppm shortened the time from planting to harvest, and increased flowering percentage, the length of flowering stems and spikes, the number of flowers per spike and diameter of flower stems. Sharma *et al.* (2006) also reported that application of GA_3 at 200ppm enhanced sprouting and resulted in maximum plant height, maximum number of leaf per plant, longer leaf length, longer spike length, more number of florets per spike, longer rachis length, floret length, number of corms per plant and with vase life longer.

Use of Paclobutazol (PP333) in gladiolus as growth regulator has not yet been reported by any researchers. The present investigation was undertaken to study the growth, flowering and yield performance of gladiolus by utilizing different doses of growth regulators and to find out the optimum level of GA_3 or Paclobutrazol for vegetative growth and quality production of gladiolus flowers.

Materials and Methods

The study was conducted at the field laboratory of USDA Allium project, Horticulture Farm, Bangladesh Agricultural University, Mymensingh during November, 2007 to April, 2008. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The treatments were: i) GA_3 50 ppm; ii) GA_3 100 ppm; iii) GA_3 200 ppm; iv) PP333 20 ppm; v) PP333 40 ppm; vi) PP333 80 ppm; vii) and untreated control. All the medium sized corms (16-25g) were treated separately with GA_3 and PP333 just 24 hours before planting. The plot size was1.05 m x1.00 m. The treated corms were planted in November 15, 2007 at a depth of 6 cm furrows maintained 25 cm row to row and 15 cm plant to plant distance. The irrigation, fertilizers and manures were applied as recommended by Anon.(1996) for gladiolus. Plant protection measures and interventions were applied for good growth of the crop when necessary. Data were recorded from randomly selected five plants except 80% emergence, 80% spike harvest and yield per plot. The self-life of the flower was assessed in the laboratory keeping flowers in the vases at room temperature. The experimental data were analyzed on MSTAT package programme and the means were compared by Least Significant Difference (LSD) following Gomez and Gomez (1984).

Results and Discussion

Effect of various growth regulators with different dosages are presented and discussed below:

Days to 80% emergence

Growth regulators showed significant effects on the days required to 80% emergence of the corms (Table 1). It was found that GA_3 treated corms @ 200 ppm required minimum time for 80% emergence (9 days) followed by GA_3 @100 ppm (10 days) whereas PP333 showed 14 days in all concentrations. Mohanty *et al.* (1994) also observed that paclobutrazol at any dose had no effect on germination of corms. However, this may be due to freshly harvested corms

and cormels undergo a period of dormancy, which has regulated by changes in the levels of endogenous promotery or inhibitory substances and require longer time. Abscisic acid was found to be the major endogenous inhibitor controlling the sprouting of corms and treatment with certain growth regulatory substances such as ethrel or GA_3 is known to promote corm sprouting (Mukhopadhyay and Banker, 1986; Misra and Singh, 1989).

Number of tillers per hill

Various growth regulators had the significant effect on number of tiller per hill. GA_3 in all concentrations performed better (3.29-3.59) whereas PP333 had negative effect in increasing number of tiller even compare to untreated control (Table 1). It is reported that the PP333 is responsible for dwarf ness of plants have been tested on millets (Devlin, 1975), which showed anti growth regulator properties for glandulous.

Days required to first spike initiation

Days required to first spike initiation was significantly influenced by the application of growth regulators. Plants from corms treated with 200 ppm GA_3 initiated inflorescence earlier (64 days) followed by 100 ppm GA_3 (66 days) whereas it was 70 days in control. Emergence of inflorescence started in plants from corms treated with 200 ppm GA_3 was 7 days earlier than that of control plants (Table 1). PP333 @ 80 ppm took the longest time (80 days) even than control. Prakash *et al.* (1998) reported that GA_3 treatment at higher concentration (150 ppm) improved all the floral characters including appearance of the flower spike in gladiolus.

Days to 80% spike initiation

Various growth regulators significantly influence the time required to complete 80% spike initiation of the plants. Corms treated with GA_3 (200 and 100 ppm) required 71 days and 73 days, respectively to 80 % spike initiation. On the other hand, treated with PP333 (@ 20 and 40 ppm, respectively) took longer time than control. It is evident that spike initiation enhanced with GA_3 treatments but PP333 delayed spike initiation in gladiolus.

Total number of spike initiation per hill

Growth regulators significantly influenced total spike initiation per hill in gladiolus. The results showed that total spike initiation was increased with the increase of GA_3 concentration. But reverse in case of paclobutrazol where it was decreased with the increase of concentration. Application of GA_3 @ 200 ppm resulted higher spikes (87.4- 91.4) while PP333 @ 80 ppm showed minimum spike (41.2%) which was even much lower than the control (Table 1).

Table 1. Effect of growth regulators on plant emergence, tiller per hill and spike initiation in gladiolus during 2006-07

Treatment		Days to 80% emergence	Number of Tillers/hill	Days to first spike initiation	Days of 80% spike initiation	Total spike initiation per hill
Control	-	13	3.0	70	79	84.7
GA_3	50 ppm	11	3.3	68	76	87.3
	100 ppm	10	3.4	66	73	89.4
	200 ppm	9	3.6	64	71	91.4
PP333	20 ppm	14	2.7	75	84	70.2
	40 ppm	14.	2.5	76	87	69.4
	80 ppm	14	2.3	80	----	41.2
LSD (0.05)	-	0.7	0.21	3.4	3.9	4.6

Days to 80% harvest of spike

Days required to 80% harvest of spike varied significantly among the treatments. Corm treated with GA_3 (100-200 ppm) took shorter days (82- 87) compared to control (90 days). The longer days (97 -100 days) was required in PP333 treated plots even than control (90 days). The result suggested that the higher concentration of GA_3 led to earlier harvesting (Table 2). On the other hand higher concentration of PP333 delayed harvesting time. This was probable that color break occurred quickly in higher concentration of GA_3 which was reversed in case of PP333. The results are in agreement with the results of Mohanty *et al.* (1994) who reported the earlier color break in the basal florets occurred when GA_3 was used @ 250 ppm.

Table 2. Effect of growth regulators on growth and flower production of gladiolus

Treatment		Days required to 80% harvest	Spike length (cm)	Rachis length (cm)	No. of florets per spike	Shelf life (days)
Control		90	58.7	46.8	12.9	10
GA_3	50 ppm	87	60.6	48.0	13.4	12
	100 ppm	83	62.1	49.2	13.6	12
	200 ppm	82	63.9	50.6	14.0	13
PP333	20 ppm	97	46.5	37.4	11.2	10
	40 ppm	100	45.4	36.0	10.4	10
	80 ppm	----	40.5	34.4	9.9	8
LSD (0.05)		2.08	1.77	1.55	0.46	0.73

Length of spike

Growth regulators had significant effects on the length of spike in gladiolus. The highest spike length (63.9 cm) was obtained from the plants treated with GA_3 200 ppm which was singnificantly different from other treatments whereas it was much lower (40.5- 46.5 cm) in the treatment of PP333 at all concentration even compared to control (58.7 cm) treatment (Table 2). The results are similar to the findings of Sindhu and Verma (1997) who reported that the spike length was increased with 250 ppm GA_3. From the results it is revealed that PP333 act as growth retardant.

Length of rachis

Different growth regulators had significant effect on the rachis length of gladiolus. The maximum rachis length (50.6cm) was measured from the corms treated with GA_3 @ 200 ppm followed by100 ppm GA_3 (49.2cm). Bhattachwjee (1984) also reported increased rachis length when the corms were treated with GA_3. On the other hand, PP333 resulted in shorter rachis length (34.4-37.4cm) even compared to control (46.8). Ginzburg (1974) reported that GA_3 stimulated the assimilate movement towards the inflorescence at the expense of corms which resulted in the better quality of spike.The shorter rachis from the corms treated with PP333 suggests its growth retardant characteristics.

Number of florets per spike

Different growth regulators showed significant effect on the number of florets per spike in gladiolus. Maximum number of florets per spike (14.00) was obtained from corms treated with 200 ppm GA_3 followed by100 ppm (13.6).The minimum number of florets per spike (9.9) was

produced by corms treated with 80 ppm PP 333 where control plots showed 12.93 florets per spike (Table 2). Results are the agreement with the findings of Mohanty *et al.* (1994) and Prakash *et al.* (1998) they concluded that GA_3 increased the number of florets per spike in gladiolus.

Shelf-life of spike

There are significant variations were found among different growth regulators in respect of shelf life of spike in gladiolus. Spikes obtained with different concentrations of GA_3 showed 12-13 day whereas 8 days required with 80 ppm PP333 in comparison with control 10 days (Table 2). It is revealed that GA_3 increase shelf-life with the increase of concentration. But in case of PP333, shelf-life decreased with the increase of concentration. Over all GA_3 @ 200 ppm showed better result in yield attributes and shelf life of flower production of gladiolus.

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FIELD EVALUATION OF SOME SELECTED LINES OF MUSK MELON AGAINST RED PUMPKIN BEETLE, *AULACOPHORA FOVEICOLLIS* LUCAS

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Abstract

Field evaluation of 12 selected lines of musk melon was assessed against red pumpkin beetle in the experimental field of Horticulture Department, Bangabandhu Shiekh Mujibur Rahman Agricultural University (BSMRAU) during October to December 2007. The abundance of the red pumpkin beetle (RPB) was assessed when damage was noticed on the cotyledonus leaves. None of the muskmelon lines were found free from the attack of RPB or escaped its damage throughout the crop period. In terms of abundance level, CM007 was found to be the most susceptible line followed by CM039, CM015 and CM001, respectively. In terms of percent leaf infestation, CM022 was found to be the most susceptible line followed by CM030, CM001 and CM006.

Introduction

Musk melon is an important cucurbitaceous crop grown in Hilly and coastal areas of Bangladesh. Cucurbits are severely attacked by a number of insect pests among which red pumpkin beetle and fruit flies are the most destructive (Alam, 1969; Butani and Jotwani, 1984). Red pumpkin beetle, *Aulacophora foveicollis* Lucas is a serious pest of musk melon (*Cucumis melo* L) particularly at seedling stage (Hussain and Shah, 1926; Nath, 1964 and Pareek and Kavadia, 1988). The adults feed voraciously on young leaves which some times necessary for resowing. There is need to find out lines of musk melon which are less infested by red pumpkin beetle. An attempt was therefore, made to evaluate some lines of musk melon against red pumpkin beetle in field condition.

Materials and Methods

The experiment was conducted in the experimental field, Department of Horticulture, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU) during October to December 2007. Twelve lines of musk melon viz., CM010 (V1), CM039 (V2), CM007 (V3), CM001 (V4), CM004 (V5), CM022 (V6), CM006 (V7), CM002 (V8), CM015 (V9), CM030 (V10), CM005 (V11) and CM003 (V12) were evaluated. The experiment was laid out in RCBD with three replications. Seeds of musk melon lines were collected from the Department of Horticulture, BSMRAU. Seeds were sown in poly bag on 7 October, 2007. The field was prepared by ploughing followed by laddering to obtain good tilth, during the 3rd week of October, 2007. The plot size was 4 m x 3 m with 1.5 m apart of each block. Recommended doses of fertilizer and agronomic practices were followed by Rashid (1993). Fifteen dayold

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seedlings were transplanted in the main field on 30 October, 2007. The number of red pumpkin beetle and leaf infestation were recorded by counting red pumpkin beetle per plant, and the number of infested and healthy leaves per plant through visual inspection. This operation was done at 7 days interval starting from one week after transplanting and continued up to fruiting stage. The percent leaf infestation per plant was calculated from the healthy and infested leaves of 4 plants per plot. Screening of musk melon lines were done under field condition with natural infestation. Less susceptible varieties to red pumpkin beetle were evaluated based on the abundance of red pumpkin beetle, its nature and quantity of damage and percent leaf infestation of plants of a plot. The analysis of variance (ANOVA) of different parameters was performed using MSTAT-C software after square root transformation. Means were separated by DMRT.

Results and Discussion

Abundance of red pumpkin beetle

The data presented in Table 1 revealed that out of 12 lines screened, none of them was found to be resistant to beetle attack in the field. The abundance of red pumpkin beetle per plant in musk melon lines were observed from seedling stage and continued up to fruiting stage of the crop (Table 1). At seedling stage, no significant difference was observed among musk melon lines with number of RPB. At this stage, the number of RPB ranged from 0.71 to 1.22 per plant. The maximum abundance was recorded in line CM003 (1.22) followed by CM002 (1.17) and CM007 (1.10) while the minimum was in CM005 (0.71). At vegetative stage, the number of RPB ranged from 0.71 to 1.29 where no significant variation was observed among musk melon lines. The maximum abundance was recorded in line CM004 (1.29) followed by CM002 (1.05) and CM007 (1.00) while lower in CM015 (0.71).

Table 1. Abundance of red pumpkin beetle infesting musk melon lines at various growth stages of plant during November to December, 2007

Lines	Mean number of red pumpkin beetle per plant at				Mean of all stages
	Seedling stage	Vegetative stage	Flowering stage	Fruiting stage	
CM010	0.88	0.88	1.05ab	1.00bc	0.95
CM039	1.05	0.88	1.17ab	1.46ab	1.14
CM007	1.10	1.00	0.88b	1.77a	1.19
CM001	0.88	0.88	0.71b	0.88bc	0.84
CM004	0.88	1.29	1.05ab	1.17abc	1.10
CM022	0.88	0.88	1.52a	1.00bc	1.07
CM006	0.88	1.00	1.05ab	0.71c	0.91
CM002	1.17	1.05	1.17ab	0.88bc	1.07
CM015	0.88	0.71	0.71b	0.88bc	0.80
CM030	1.05	0.88	1.17ab	0.71c	0.95
CM005	0.71	0.88	0.88b	1.17abc	0.91
CM003	1.22	0.88	0.71b	0.88bc	0.92
Range	0.71-1.22	0.71-1.29	0.71-1.52	0.71-1.77	
CV(%)	34.70	38.30	32.23	31.77	

In a column, means followed by common letters under the same factor are not significantly different at 5 % level by DMRT values.
Figures are transformed values based on square root transformation ($\sqrt{x} + 0.5$).

At flowering stage, significant variation was observed on the abundance of RPB among musk melon lines. Higher number of RPB per plant was recorded in line CM022 (1.52) which was statistically similar to those of CM039 (1.17), CM002 (1.17), CM030 (1.17), CM010 (1.05), CM004 (1.05) and CM006 (1.05), respectively. However, the lower and similar

abundance was observed in CM001 (0.71), CM015 (0.71) and CM003 (0.71), and that of CM007 (0.88) and CM005 (0.88).

At fruiting stage, significant variation was observed on the abundance of RPB. The maximum abundance per plant was recorded in line CM007 (1.77) which was statistically similar to those of CM039 (1.46), CM004 (1.17) and CM005 (1.17), respectively. Lower and similar abundance was observed in CM006 (0.71) and CM030 (0.71) but CM001 (0.88), CM002 (0.88), CM015 (0.88) and CM003 (0.88) lines were also identical.

From the above, it may be said that mean of all stages indicated that the maximum abundance was observed in line CM007 (1.19) followed by CM039 (1.14) and CM004 (1.10) while minimum in CM015 (0.80) followed by CM001 (0.84).

Percent leaf infestation

Percent leaf infestation per plant on different lines of musk melon at seedling, vegetative and flowering stages of plant growth were presented in Table 2. At seedling stage, no significant variation was observed on percent leaf infestation among different lines of musk melon. Percent leaf infestation ranged from 53.33 to 100% where the highest percent leaf infestation was recorded in CM003 and the lowest in CM001.

Table 2. Percent leaf infestation per plant in musk melon lines infested by red pumpkin beetle at different growth stages of plant during November to December, 2007

Lines	% leaf infestation per plant at			Mean of all stages
	Seedling stage	Vegetative stage	Flowering stage	
CM010	82.14	61.24ab	68.98abc	70.79
CM039	81.02	36.76b	58.14abc	58.64
CM007	62.06	48.10ab	57.75abc	55.97
CM001	53.33	45.85b	43.90bc	47.69
CM004	77.78	77.13a	56.52abc	70.48
CM022	77.78	64.04ab	81.30a	74.37
CM006	63.49	36.35b	54.80abc	51.55
CM002	78.33	53.95ab	54.20abc	62.16
CM015	80.00	59.35ab	36.94c	58.76
CM030	67.41	77.88a	76.85ab	74.05
CM005	63.81	46.06b	70.32abc	60.06
CM003	100	37.85b	73.21ab	69.69
Range	53.33 -100	36.35 - 77.88	36.94 - 81.30	
CV(%)	28.12	29.50	30.14	

In a column, means followed by common letters under the same factor are not significantly different at 5 % level by DMRT values.

At vegetative stage, significant variation was observed on percent leaf infestation among 12 lines of musk melon. The maximum percent leaf infestation was recorded in CM030 (77.88%) which was statistically similar to CM004 (77.13%), CM022 (64.04%), CM010 (61.24%), CM015 (59.35%), CM002 (53.95%) and CM007 (48.10%), respectively. The lowest percent leaf infestation was recorded in CM006 (36.35%) which was statistically similar to CM039 (36.76%) followed by CM003 (37.85%), CM001 (45.85%) and CM005 (46.06%), respectively. At fruiting stage, significant variation was also observed on percent leaf among different lines of musk melon. The maximum percent leaf infestation was recorded in CM022 (81.30%) which was statistically similar to CM030 (76.85%), CM003 (73.21%), CM005 (70.32%), CM010 (68.98%), CM039 (58.14%) and CM007 (57.75%). The lowest percent leaf infestation was recorded in CM015 (36.94%) followed by CM001 (43.90%). It was observed that mean of all

stages of percent leaf infestation was higher in CM030 (74.05%) followed by CM010 (70.79%) while lower in CM001 (47.69%) and CM006 (51.55%).

Number of lady bird beetle

Fig. 1 revealed that the maximum number of lady bird beetle was recorded in lines CM004 followed by CM006, CM039, CM001, CM022 and CM002, respectively. The minimum number of lady bird beetle was in line CM015, CM005 and CM003. Lady bird beetle was not observed in line CM010, CM007 and CM030, respectively.

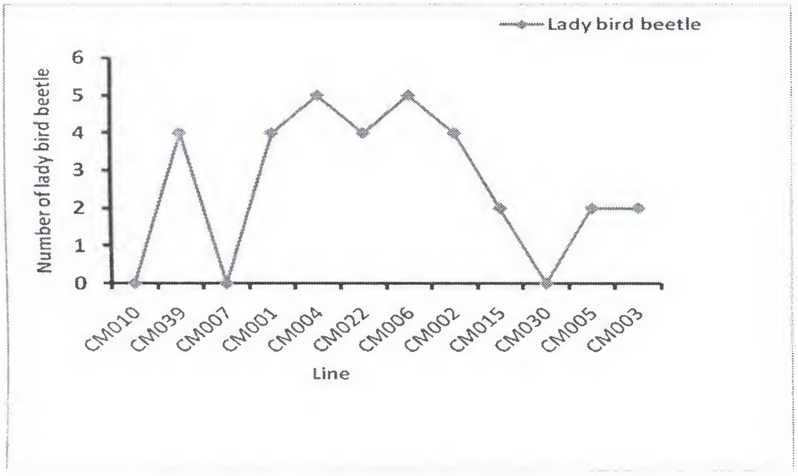

Fig. 1. Number of lady bird beetle per plant on different lines of musk melon during November to December 2007

Conclusion

None of the 12 musk melon lines either remained free from the attack of red pumpkin beetle or escaped its damage throughout the crop period. However, differences existed in the abundance levels of this pest and percent leaf infestation. In terms of the number of RPB, the line CM007 was found to be the most susceptible line followed by CM039, CM015 and CM00, respectively and rest lines were found to be less susceptible.

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SURVEY ON POSTHARVEST PRACTICES AND LOSSES OF BANANA IN SELECTED AREAS OF BANGLADESH

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Abstract

A study was conducted to analyze the postharvest practices and losses of banana during November 2008 to June 2009. Six districts including two urban areas were selected for the study. Some indigenous post harvest practices were observed where banana was covered with banana leaves and kept under the shade of trees. The usual packaging practices were mainly bamboo made baskets lining with banana leaves and covering with gunny sheets at retailers' level. None of the arathdars was involved in packaging. The postharvest losses were reported mainly at harvesting (2.13%), handling from orchard to selling point by the growers and beparies involved in harvesting as well as short distance beparies (2.75 %), handling from selling point to distant market as well as long distance beparies (9.0), arathdars level (7.25%), retailers level (3.0%) and after buying by the consumers (2.5%). The gross post harvest losses from harvesting to consumption of banana were calculated as 26.63%.

Introduction

Banana (*Musa sapientum* L) is one of the major fruit crops in Bangladesh in respect of production and area (BBS, 2006). It is available through out the year and consumption rate is higher than any other fruit. It is one of the cheapest, delicious and most nourishing of all fruits. The origin of banana is southern part of China (Bose, 1985). The fruit is widely grown in sub-tropical Asia and has been successfully cultivated in Hawaii and South Africa (Scott, *et al.*, 1982). Banana is grown in 1681 hectares of land and its production is 40195 MT in Bangladesh (BBS, 2006). Banana is a highly perishable fruit. The perish ability of the fruit is attributed to immense physiological changes after harvest (Momen *et al.* 1993).

Banana is susceptible to disease infestation causing post-harvest losses due to lack of proper pre-harvest and postharvest management practices. Banana has a short shelf life and vulnerable to environmental stress especially high temperature. A considerable amount of banana fruit losses occur every year during harvesting, sorting, storing, transportation, and selling. However, very little information is available on the postharvest practices and losses of banana at growers, beparies, pikars, arathdars, retailer and consumers' levels. The results of this study will provide valuable information on the practices and losses of banana, which will help to carry out future research plan for developing appropriate postharvest practices to reduce postharvest losses of banana. With this view in mind, the present study was been undertaken to analyze the existing postharvest practices and losses of banana at different levels like growers, beparies (long and short distance), arathdars, retailers and consumers' level.

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Materials and Methods

Sample size and population

Four levels viz., growers, arathdars, beparis, and retailers were selected from eight banana growing areas namely, Jhenaidah, Jeesore, Kustia, Gaibandha, Joypurhat, Tangail (Madhupur), Gazipur, Narsingdi for getting answers to research questions by using pre-tested questionnaires. These initial respondents were randomly selected from a list of retailers. Beparies were selected based on the list of names provided by the retailers interviewed. Arathdars and growers were selected based on the list of names provided by the beparies and retailers. Consumers were selected from two urban areas namely; Gazipur and Dhaka city based on the response of respondents or retailers. Ten respondents were randomly selected for each level (growers, beparies, arathdars, retailers and consumers) and location and it was replicated for three times. Thus the total sample size and populations were: 10 respondents X 4 levels X 8 banana growing areas X 3 replications + 10 respondents X 2 urban areas X 3 replications = 1020 numbers (Table 1). Data regarding postharvest practices and losses with other relevant factors were collected from growers, beparies, arathdars, retailers and consumers in the above regions during the study periods of November 2008 to June 2009.

Table 1. Overview of sample size and population

Name of crop	Sample size by agent		Sample size by district		Total
	Level	Respondents	Growing area	Respondents	
Banana	Growers'	240	Jhenaidah	120	120
	Beparies'	240	Jessore	120	120
	Arathdars'	240	Kustia	120	120
	Retailers	240	Gaibandha	120	120
	-	-	Joypurhat	120	120
	-	-	Tangail (Madhupur)	120	120
	-	-	Gazipur	120	120
	-	-	Narsingdi	120	120
	Consumers'	60	Dhaka	30	30
			Gazipur	30	30
Total		1020		1020	1020

Definition of (6) channels

Growers: Growers produces banana and sold their produce to the bepari through arathdar. Sometimes, they sold their garden to the bepari directly.

Bepari: There are two kinds of beparies: local or coming from other districts like Dhaka, Chittagong, Khulna, Jessore, Barisal etc. They bought harvested banana from growers and pikars in the local markets through the local arathdars. The second group of the beparies bought banana orchards directly from the growers or other intermediates, harvest banana fruits by their own management and sell banana to the arathdars operating in the local market or dispatch it to arathdars to other big markets.

Arathdar: Arathdars are big traders. They are commission agents and have a fixed establishment in the market and operated between beparies and retailers. They took commission from growers and beparies.

Retailer: Retailer is the last link in the banana selling. Retailers were found to operate with permanent shops in the banana growing and urban areas. They mostly bought banana from the

beparies through arathdar and sell it to the local or urban market and sometimes in urban residents, the ultimate consumers.

Consumer: The people who bought banana from retailers with their requirement for consumption are known as consumer. They are the last respondent group of this survey.

Results and Discussion

Varieties

It was found that growers at different locations cultivated four commercial cultivars of banana: Champa, Sagar, Sabri and Kabri. Champa was cultivated by 40% of the growers of all the districts except Gaibandha (45%), Tangail (10%) and Joypurhat (5%). Similarly Sabri was cultivated by 40% of the growers of Jhenaidah, Jessore and Kustia compared to 50% of the growers of Joypurhat and 30% of Gazipur and Narsingdi (Table 2). The majority of the growers (60%) of Tangail cultivated Sagar while 40% of the growers of Gaibanda and Joypurhat cultivated the same variety. Kabri was the least cultivated variety which ranged between 5 to 10% of the growers of all the selected locations.

Table 2. Location- wise and variety-wise distribution of banana growers

Variety	Varieties cultivated by growers (as percentage)							
	Jhenaidah	Jessore	Kustia	Gaibanda	Joypurhat	Tangail (Modhupur)	Gazipur	Narsingdi
Champa	40	40	40	45	5	10	40	40
Sagar	15	15	15	40	40	60	20	20
Sabri	40	40	40	10	50	20	30	30
Kabri	5	5	5	10	5	10	10	10

Identification of maturity and selection of harvesting stages

All the respondents in all the eight locations informed that fruit size, colour and fullness of finger were the selection criteria of maturity index of banana fruits. When the fruits attain full size, angularity and bears attractive colour, the growers or beparies get ready for harvesting. Eighty percent respondents in Jhenaidah, Jessore, Gaibandha, Joypurhat, Tangail (Modhupur) and seventy percent in Kustia and Gazipur and hundred percent in Narsingdi area mentioned that harvesting stage of banana was also determined by the upper and lower size of banana bunches. The respondents' opined that fruits harvested before getting fullness of finger or appearing colour was not suitable for marketing (Table 3).

Table 3. Criteria for maturity identification and selection of harvesting stage in different locations

Location	Basis of maturity Identification (%)			Harvesting stage based on different maturity criteria (%)		
	Fruit size	Colour	Fullness of finger	Angularity/fullness of finger	Size of upper and lower bunch	Colour
Jhenaidah	100	100	100	100	80	100
Jessore	100	100	80	100	80	100
Kustia	100	100	80	100	70	100
Gaibandha	100	100	100	100	80	100
Joypurhat	100	100	100	100	80	100
Modhupur	100	100	70	100	80	100
Gazipur	100	100	80	100	70	100
Narsingdi	100	100	100	100	100	100

Harvesting period and time of harvest on the day

It was reported by the respondents that harvesting period of the banana was from November to June in a year in all the eight locations Jhenaidah, Jessore, Kustia, Gaibandha, Joypurhat, Tangail (Modhupur), Gazipur and Narsingdi (Table 4). Most of the growers harvested banana in March to June based on fruit colour, angularity and size of upper and lower bunch.. Most harvesting was done in morning but sometimes performed late in the afternoon depending on the purpose of marketing or agreement to the beparies from distant location.

Table 4. Location- wise banana harvesting period and time of harvest on the day by the growers

Location	Harvesting period (% over total harvesting)				Time of harvest on the day (% of respondents)	
	Nov-Dec	Jan-Feb	March-April	May -June	Morning	Afternoon
Jhenaidah	10	5	45	40	70	30
Jessore	10	5	45	40	80	20
Kustia	10	5	45	40	70	30
Gaibandha	5	5	50	40	70	30
Joypurhat	10	5	45	40	80	20
Modhupur	10	30	30	30	70	30
Gazipur	15	20	35	30	80	20
Narsingdi	15	20	35	30	70	30

Postharvest practices

Some indigenous postharvest practices were observed in all the growing areas mostly by the growers and/or beparies who were involved in the harvesting process. These practices were banana covered with banana leaves before carrying to different places. Bepari were not practices in sorting and grading but arathdars involved with sorting and grading according to the upper and lower bunches of banana. Chemicals for insect control and ripening were practiced in selected areas. Most of the arathdars ripened banana by tundur, heaping and smoking treatments ((Table 5).

Mode of transportation

Means of transportation used mainly depends on the volume of produce handled and distance of the market from the growing area. Growers having small quantity of marketable banana generally used rickshawvan and nosimon whereas for large volume both growers and intermediaries (bepari) used van, nosimon, bus and truck for local and distant market respectively (Table 6).

Postharvest losses of banana

Losses during harvest: The losses of banana were estimated based on the responses of the respondents. The losses of banana during harvest were 4% in Gaibandha and Joypurhat while it was 2% in Jhenaidah, Jessore and Kustia and 1% in Gazipur, Modhupur and Narsingdi. On an average, 2.13% losses were occurred at growers' level during harvesting (Table 7). According to the growers' opinion, these losses were mostly due to disease and pest infestation at pre-harvest condition but expressed at harvesting period. They also opined that a small proportion of these losses also occurred due to adverse weather condition especially natural calamity, cultivar, inappropriate time of harvest, careless harvesting and handling practices. Madan and Ullasa (1990) reported that postharvest losses in banana depend largely on cultivar, time of harvest, mode of transport, handling practices, and peak marketing seasons in different regions.

Table 5. Postharvest techniques used by respondents of different locations

Particulars	Jhenaidah				Jessore				Kustia				Gaibandha			
	Gr.	Be.	Ar.	Re.	Gr.	Be.	Ar.	Re	Gr.	Be.	Ar.	Re.	Gr.	Be.	Ar.	Re.
Covered with banana leaves	40	60	50	-	30	60	45	-	40	60	60	-	40	50	45	-
Sorting	-	-	70	-	-	-	70	-	-	-	70	-	-	-	60	-
Grading	-	-	60	-	-	-	60	-	-	-	60	-	-	-	50	-
Ripening method (Tundur, ripening agent, heaping etc,)	-	-	70	-	-	40	70	-	-	-	70	-	-	40	60	-
Chemicals (for colour development etc.)	20	-	-	-	20	-	-	-	20	-	-	-	20	-	-	-

Gr=Grower, Be= Bepari, Ar= Arathdar, Re= Retailer.

Table 5. (Cont'd.) Postharvest techniques used by respondents of different locations

Particulars	Tangail (Modhupur)				Joypurhat				Narsingdi				Gazipur			
	Gr.	Be.	Ar.	Re.	Gr.	Be.	Ar.	Re.	Gr.	Be.	Ar.	Re.	Gr.	Be.	Ar.	Re.
Covered with banana leaves	40	70	50	-	30	70	45	-	40	45	60	-	45	50	40	-
Sorting	-	-	70	-	-	-	70	-	-	-	60	-	-	-	80	-
Grading	-	-	60	-	-	-	40	-	-	-	60-	-	-	-	30	-
Ripening method (Tundur, ripening agent, heaping etc,)	-	-	50	-	-	-	50	-	-	-	60	-	-	-	70	-
Chemicals (for colour development, insect and disease control etc.)	60	-	-	-	60	-	-	-	60	40	40	-	60	40	-	-

Table 6. Mode of transport from local selling point to distant market

Particulars	Percent of total respondents														
	Jhenaidah					Jessore					Kustia				
	HL.	RV.	AD.	BS.	TR.	HL.	RV.	NM.	BS.	TR.	HL.	RV.	NM.	BS.	TR.
Grower	10	45	45	-	-	10	40	50	-	-	10	55	35	-	-
Bepari	-	10	10	20	60	-	10	10	20	60	-	10	10	20	60
Arathdar	-	30	30	-	40	-	30	30	-	40	-	30	30	-	40
Retailer	10	40	45	5	-	10	40	45	5	-	10	40	45	5	-

Table 6 (Cont'd.) Mode of transport from local selling point to distant market

Particulars	Percent of total respondents														
	Gaibandha					Joypurhat					Modhupur				
	HL	RV	NM.	BS	TR	HL	RV	NM	BS	TR	HL	RV	NM	Pick-up	TR
Grower	10	55	35	-	-	20	50	30	-	-	10	55	35	-	-
Bepari	-	10	10	-	80	-	10	10	-	80	-	10	10	20	60
Arathdar	-	60	-	10	30	-	60	30	5	5	-	60	40	-	-
RetaiLer	10	60	20	10	-	15	60	20	5	-	-	30	50	20	-

Table 6 (Cont'd.) Mode of transport from local selling point to distant market

Particulars	Percent of total respondents									
	Gazipur					Narsingdi				
	HL	RV	NM	BS	TR	HL	RV	NM	BS	TR
Grower	10	55	35	-	-	20	55	25	-	-
Bepari	-	10	10	10	70	-	10	10	10	70
Arathdar	-	50	-	-	50	-	60	40	10	-
Retailer	20	50	30	-	-	20	50	30	-	-

HL=Head load, RV= RickshawVan*, AL= Alamdanga, NM=Nosimon** BS= Bus,TR=Truck, Tri-cycle operated manually
**Nosimon-A local made tri-cycle operated by shallow-engine

Table 7. Proportion of postharvest losses of bananas at growers/beparies levels with respect to different phases/points of supply chain

Phases/point of supply chain		Percent losses															
		Growers/beparies involved in harvesting								Beparies not involved in harvesting							
		Jhenaidha	Jessore	Kustia	Gaiban dha	Gazi pur	Joydeb pur	Modhu pur	Nar singdi	Jhenai dah	Jessore	Kustia	Gaiban dha	Gazi pur	Joydeb pur	Modhu-pur	Narsi ngdi
During harvesting		2.0	2.0	2.0*	4.0	10	4.0	1.0	1.0	-	-		-	-		-	-
Handing transport from harvest (orchard) to selling/loading point of local market										3.0	30	3.0	4.0	1.0	4.0	2.0	2.0
Total		2.0	2.0	2.0	4.0	1.0	4.0	1.0	1.0	3.0	3.0	3.0	4.0	1.0	4.0	2.0	2.0
Average		2.13								2.75							
Handling/ transport from purcha-sing/ loading point to selling point pf distant market	During loading	-	-	-	-	-	-	-		2.0	2.0	2.0	2.0	1.0	2.0	2.0	1.0
	Loading distance	-	-		-	-	-	-	-	6.0	6.0	6.0	6.0	4.0	6.0	4.0	6.0
	During delivery of goods	-		-	-	-	-	-	-	2.0	2.0	2.0	2.0	1.0	2.0	2.0	1.0
Total		-	-	-	-	-	-	-	-	10	10	10	10	6	10	8.0	8.0
Average		-								9.0							

Losses during handling/transport from harvest (orchard) to selling point of local and distant market

On an average, 2.75% losses were occurred at beparies (short distance) level during handling or transport from orchard to the selling point in local market (Table 7.). Maximum losses of 4% occurred in Gaibandha and Joypurhat followed by 3% in Jhenaidha, Jessore and Kustia and 2% in Madhupur and Narsingdi. The lowest loss of 1% occurred in Gazipur which might be occurred due to its short distance compared to other selected districts of Bangladesh. The average loss during loading of banana was 2% in all the locations while it was only 1% in Gazipur and Narsingdi. The lowest losses in Gazipur and Narsingdi might be occurred due to its short distance from Dhaka city compared to others. The maximum loss of 6% occurred during transportation of banana in all the locations where the loss of 4% occurred in Gazipur and Madhupur. Some losses were also observed during delivery of banana and it was estimated at 2% in most locations. Thus on an average, 9.0% postharvest losses were occurred at beparies (long distance) level (Table 7). They reported that these losses might be due to careless handling, transporting mode, delayed transportation due to unavoidable reasons and over loading tendency. The similar findings were also found by Madan and Ullasa (1990).

Losses at arathders level: The average losses of banana were 8.0, 8.0., 8.0, 10.0, 6.0., 10.0, 8.0. and 7.0% at the arathdars level in Jhenaidah, Jessore, Kustia, Gaibandha, Gazipur, Joypurhat, Modhupur and Narsingdi, respectively. On an average, 7.25% losses occurred at arathdars level. They opined that these losses might be due to over heating, lack of marketing and storage facilities of banana (Table 8.).

Table 8. Proportion of postharvest losses of bananas at arathdars levels

Level of losses	Percent losses							
	Jhenaida	Jessore	Kustia	Gaibandha	Gazipur	Joypurhat	Tangail (Modhupur)	Narsingdi
From ripening to selling point	8.0	8.0	8.0	10.0	6.0	10.0	8.0	7.0
Average	7.25							

Table 9. Proportion of postharvest losses of bananas at retailers and consumers levels

Level of losses	Percent losses									
	Retailer								Consumer	
	Jhenaida	Jessore	Kustia	Gaiban-dha	Gazi-pur	Joy-purhat	Modhu-pur	Nar-singdi	Dhaka	Gazipur
During harvest	-	-	-	-	-	-	-	-	-	-
Handling/transport from orchard to selling point of local market	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-	-
Cracking	1.0	1.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0
Rotting	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	1.0
Total	3.0	3.0	3.0	4.0	3.0	3.0	3.0	3.0	3.0	2.0
Average	3.0								2.5	

Losses at retailers' level and after buying to consumption: It was observed that 3.0, 3.0, 3.0, 4.0, 3.0, 3.0, 3.0 and 3.0% losses were found at retailers' level in Jhenaidah, Jessore, Kustia, Gaibandha, Gazipur, Joypurhat, Modhupur and Narsingdi. It was also noted that 3.0 and 2.0% losses of banana were found at the level of consumers in Dhaka and Gazipur areas. On an average, 2.5 and 3.0% losses of banana were found at consumers' and retailers level in selected areas (Table 9). They reported that these losses might be occurred due to facing fruit broken and

rotten problem during handling and marketing. Similar observation was made by Madan and Ullasa (1990).

Conclusion

Some locally adopted postharvest practices were found to be followed by different points in banana supply chain. The usual postharvest practices followed by the growers and/or beparies were banana covered with banana leaves before carrying to different places. Beparies were not involved with sorting and grading of banana but mainly followed at arathdars level based on upper and lower bunches of banana. Both short and long distance losses of banana at beparies level was mainly due to rough handling, overloading tendency and delayed transportation due to unavoidable reasons. The postharvest loss of banana at arathdars level was due to overheating, inadequate marketing and storage facilities. The loss of retailers' level was mainly unused of lining material during transport of banana from arath or collecting point to selling point and unfavourable road condition in some selected areas. Postharvest losses of banana were recorded as 2.13% at growers level, 11.75% at beparies level (short distance beparies 2.75 and long distance beparies 9.0%), 7.25% at arathdars level, 3.0% at retailers and 2.5%. at consumers level. Therefore, the gross post harvest losses from harvesting to consumption of banana were calculated as 26.63%. These losses may be minimized through improved postharvest practices like proper harvesting stage, proper method of pre-cooling, sorting of infested and damaged banana, grading on the basis maturity, size and shape and washing with clean/ chlorinated water before shipment to different places. Before loading and unloading, the banana should be handled carefully by the labour and other persons who are involved with banana storage and marketing. Standard packaging size and avoiding overloading tendency from collecting point to destination market may be other important tools to minimize the postharvest losses of banana.

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EFFECT OF FOUR SELECTED CHEMICALS ON THE INCIDENCE OF *MUNGBEAN YELLOW MOSAIC VIRUS* AND SEED YIELD OF MUNGBEAN

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Abstract

A field experiment was conducted to evaluate the efficacy of Furadan 5G (carbofuran), Dursban 20EC (chloropyrifos), Ripcord 10EC (cypermethrin) and Admire 200SL (imidachloprid) for the management of mungbean yellow mosaic virus at Bangladesh Agricultural Research Institute, Joydebpur, Gazipur during March to June 2008. At 50 DAS the lowest disease incidence and severity was recorded for Admire received plants and the highest was found in control. Incidence of whitefly and *Mungbean yellow mosaic virus* (MYMV) was positively and seed yield was negatively correlated with white fly population. All the chemicals decreased MYMV incidence but Admire (imidachloprid) performed the best results which reduced disease incidence by 30.86% and the seed yield increase by 20.06% over control.

Introduction

Mungbean is an important pulse crop having global economic importance as dietary ingredient of the staple food. The average yield of mungbean is 617.50 kg/ ha in Bangladesh which is quite low as compared to potential yield of this crop other pulse growing countries (Anon. 2006). Earlier mungbean as a food legume was considered as the cheap source of protein but now-a-days all pulses has gone out of the reach of general people due to its drastic reduction in production vis-vis price escalation. Generally grain legumes are limited by the low sulfur containing amino acids like cysteine and methionine. Both of these amino acids are comparatively more in mungbean (Engel, 1978). So far twenty diseases of mungbean have been recorded, of which viral diseases are the most damaging to the crop (Rashid and Bakr, 2007). Yellow mosaic is the most destructive yield damaging viral disease of mungbean in Bangladesh (Jalaluddin and Shaikh, 1981). The causal organism is *Mungbean yellow mosaic virus* (MYMV) which is transmitted nonpersistently by whitefly (*Bemisia tabaci*) and grafting but not by sap inoculation (Niriani, 1960). According to Rashid and Bakr (2007) MYMV causes up to 85% yield loss when infection starts from the 4th week of sowing. The control of insect vector is an important tactic for managing yellow mosaic disease of mungbean. Some chemicals were found to be effective in reducing the incidence of yellow mosaic disease (Borah, 1996). Though injudicious application of these chemicals pollute the environment and cause health hazard but other alternate approaches like plants extracts and cultural practices were not found effective against the vector. Considering the facts stated above, the present investigation was undertaken to determine the efficacy of four selected chemicals in reducing the incidence and severity of *Mungbean yellow mosaic virus* and to determine the relationship among the virus, vector and seed yield of mungbean.

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Materials and Methods

The experiment was conducted at the experimental farm of the pulses pathology sub-division of Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, Bangladesh during the period March to June 2008. Seeds of mungbean variety BARI Mung-4 were used and the experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The size of the plot was 4.0 m x 2.4 m and crop was sown in six rows per plot where row to row distance 40 cm and plant to plant distance10cm. The seeds were sown in the field on 15th March, 2008 @ 40 kg/ha and seeds were placed continuously in lines at the depth of 3-4 cm. Cowdung, Urea, TSP and MP was applied as recommended by Pulses Research Centre. Five different treatments of the experiment were; T_1 = Application of Furadan 5G (carbofuran) @ 1.5kg a.i/ha at sowing, T_2 = Application of Dursban 20 EC (chloropyrifos) @ 2ml/litre at 15, 25, 35 and 45 days after sowing, T_3 = Application of Ripcord 10 EC (cypermethrin) @ 1ml/litre at 15, 25, 35 and 45 day after sowing, T_4 = Application of Admire 200SL (imidacloprid) @ 1ml/liter of water at 15, 25, 35 and 45 day after sowing and T_5 = Untreated (control). All seeds were treated with Vitavax-200 @ 2gm/kg before sowing. Ten plants per plot were tagged randomly from six inner rows leaving 15 cm from the corner. These plants were used for recording data on whitefly. Whitefly was counted *in sito* from fully unfolded top leaves of the plant. Data was recorded at an interval of 10 days commencing from first incidence and counted up to maturity of crop. The incidence of mosaic was recorded three times at 10 days interval i.e., 30 days after sowing (DAS). The mosaic infected plants were identified as described by Ahmed (1985). Assessment of different chemicals against MYMV was carried out on the basis of % disease infection and scored them using recommended 1-9 arbitrary scale (Singh *et al.* 1995) at 30, 40 and 50 DAS.

Disease Severity	Percent Infection	Infection Category	Reaction Group
1	1-10	Resistant	RR
3	11 -20	Moderately resistant	MR
5	21-30	Moderately susceptible	MS
7	30-50	Susceptible	S
9	More than 50%	Highly susceptible	HS

The data obtained for different characters were analyzed statistically by using MSTATC program and the means were compared according to LSD (Least Significant Difference) at 5% level of probability (Gomez and Gomez 1984).

Results and Discussion

Whitefly incidence

Four selected chemicals were used as treatments for managing *Mungbean yellow mosaic virus* which showed statistically significant differences among the treatments in whitefly population. The minimum (1.72) number of whitefly per 5 leaves was recorded for treatment T_4 which was closely followed by treatment T_1 (2.65) and T_3 (2.78). The maximum (5.17) number of whitefly per 5 leaves was recorded for treatment T_5 which was followed by T_2 (4.00). The highest population reduction (66.63%) over control was recorded in T_4 treatment and the lowest (22.63%) in T_2 (Table 1). The present findings are relevant with Cahill *et al.* (1995) who reported that Imidachloprid (a systemic chloronicotinyl insecticide) gained major importance

for control of *Bemisia tabaci* in both field and protected crops, in view of extensive resistance to organophosphorus, pyrethroid and cyclodiene insecticides.

Table 1. Effect of selected chemicals on the incidence of white fly population in MYMV infected mungbean plants

Treatment	No. of whitefly per five leaves	Population reduction over control (%)
T_1 = Furadan (Carbofuran)	2.65 bc	48.74
T_2 = Dursban (Chloropyrifos)	4.00 ab	22.63
T_3 = Ripcord (Cypermethirin)	2.78 bc	46.09
T_4 = Admire (Imodachloprid)	1.72 c	66.63
T_5 = Control (Untreated)	5.17 a	--
LSD (0.05)	1.46	--
CV (%)	22.33	--

Disease incidence

Remarkable variation was recorded in disease incidence due to application of different chemicals at 30 DAS. The lowest (12.12%) disease incidence was recorded in treatment T_4 (Fig. 1) which was statistically identical (15.48%) with treatment T_1. The maximum (21.57%) disease incidence was recorded in treatment T_5 which was followed by T_2 (20.88%). At 40 DAS a significant difference was recorded in disease incidence for different treatments. The lowest (23.26%) disease incidence was recorded in treatment T_4, while the highest (48.74%) in T_5. At 50 DAS different treatments showed a significant variation in respect of incidence of *Mungbean yellow mosaic*. The lowest (34.40%) disease incidence was recorded in T_4 treatment. The highest (65.26%) disease incidence was recorded in treatment T_5. The results are of in agreement with the finding of Singh *et al.* (1982). They observed that application of chemicals resulted more vigorous vegetative growth allowing the plants to escape viral infections and effect of infection. The findings of present study are also relevant with the results of Saran and Giri (1990). They suggested that Admire (imidacloprid) might have great impact in reducing disease incidence and severity of yellow mosaic disease and producing disease free plants.

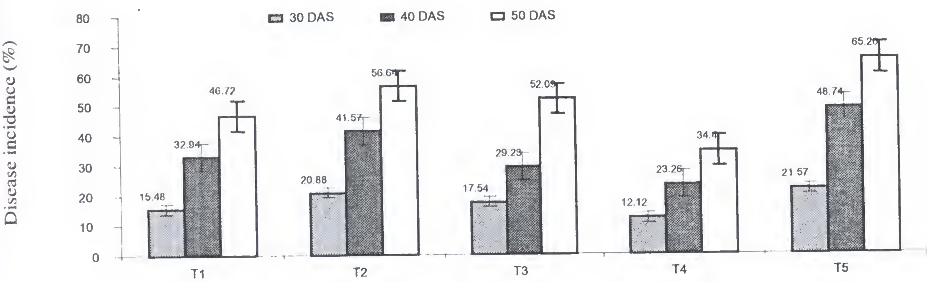

Fig. 1. Effect of four different chemicals on the incidence of MYMV of mungbean.

Disease severity

Different chemicals were used for managing *Mungbean yellow mosaic virus* in this trial showed statistically significant variation for disease severity calculated at 30, 40 and 50 DAS (Fig. 2). At 30 DAS, the disease severity was recorded lowest (1) from treatment T_1 followed by T_3 and T_4 while the highest disease severity (3) for treatment T_2 and T_5. At 40 DAS, the lowest disease severity (3) was recorded from treatment T_4 while the highest severity (7) in T_5 and the rest three treatments (T_1, T_2 and T_3) showed the same disease severity (5). At 50 DAS, the lowest disease severity (5) was recorded for treatment T_4. On the other hand the highest disease severity was recorded for treatment T_5 (9) and the treatment T_1, T_2 and T_3 showed the similar disease severity (7).

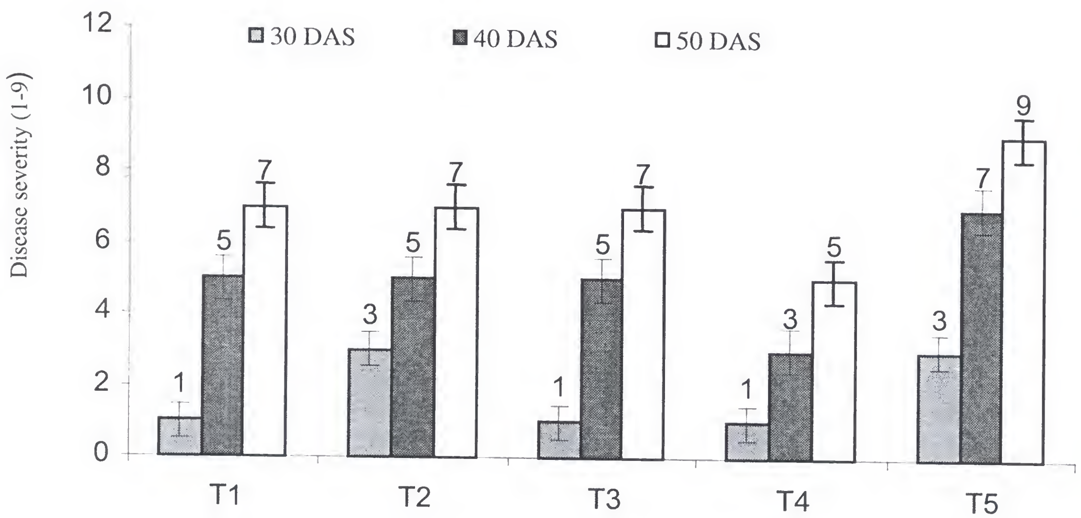

Fig. 2. Effect of four different chemicals on the severity of MYMV of mungbean

Seed yield

The effect of four different chemicals on the seed yield of mungbean against the infection *Mungbean yellow mosaic virus*es were recorded significant difference and presented in the Table 2. The highest seed yield (999.06 kg/ha) was recorded in treatment T_4, while the lowest yield (730.31 kg/ha) in T_5 (Table 2). The maximum yield increased (22.90%) over control was recorded for T_4 treatment and the minimum (3.34%) in treatment T_2. Jain *et al.* (1995) also reported that Admire (imidachloprid) have positive impact in reducing disease incidence and severity of yellow mosaic disease which performed better in respect of seed yield.

Table 2. Effect of selected chemicals on seed yield of mungbean against MYMV infection

Treatment	Seed yield (gm/plot)	Seed yield (kg/ha)	Seed yield increased over control (%)
T_1= Furadan (Carbofuran)	877.00 b	913.54 b	20.06
T_2= Dursban (Chloropyrifos)	725.30 d	755.52 d	3.34
T_3= Ripcord (Cypermethirin)	836.60 c	871.46 c	16.20
T_4= Admire (Imidachloprid)	959.10 a	999.06 a	22.90
T_5= Control (Untreated)	701.10 e	730.31 e	--
LSD (0.05)	15.02	--	--
CV (%)	0.97	--	--

Relationship between the number of white fly and MYMV incidence

A strong positive correlation exists between the number of white fly and MYMV incidence, which indicated that higher number of white fly maximize the MYMV incidence. The results of the study are in conformity with the study of Aftab *et al.* (1992) and Nath (1994) who observed a positive correlation between incidence of MYMV and population size of *B. tabaci*. A linear regression line was fitted between the number of white fly per 5 leaves and MYMV incidence (Fig.3) at 50 days after sowing. The correlation of coefficient (x) showed 8.2376 and the contribution of regression (R^2=0.9176) was 91%.

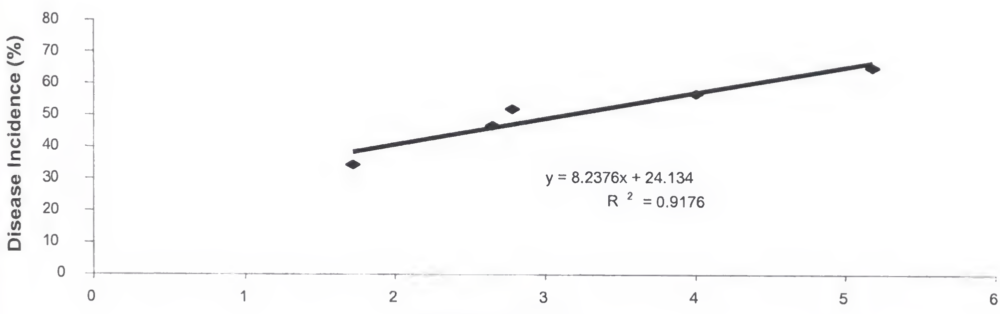

Fig. 3. Relationship between the number of white fly and MYMV incidence obtained from four different chemical treatments.

Relationship between the incidence of MYMV and seed yield

There was a negative correlation observed between the incidence of MYMV and total seed yield, which indicated that higher incidence of MYMV conversely minimize the total seed yield. The results of the findings are similar with the findings of Bisht *et al.* (1988) and Gill *et al.* (1999). They observed that MYMV infection at early stage of crop growth maximize disease incidence which caused much higher reduction of seed yield. A linear regression line was fitted between the incidence of MYMV and seed yield recorded at 50 days after sowing (Fig. 4). The correlation of coefficient (x) was negative (-9.3603) and the contribution of regression (R^2 =0.9312) was 93%.

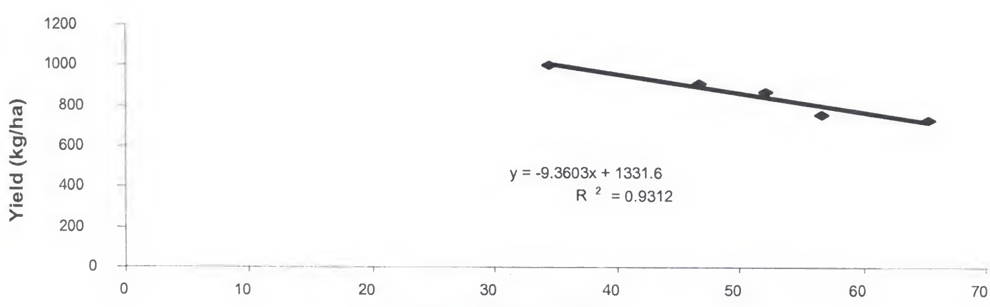

Fig. 4. Relationship between the incidence of MYMV and seed yield of mungbean obtained from four different chemical treatments

Conclusion

In the present study application of Admire (imidachloprid) was found to be the best treatment in reducing the white fly infestation as well as minimizes the incidence and severity of *Mungbean yellow mosaic virus* as well as maximum seed yield. Use of indirect method of viral disease management through control of vector is a possible way. A positive correlation was found between the infestation of white fly and MYMV incidence. A negative correlation also found between the incidence of MYMV and total seed yield of mungbean.

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EFFECT OF BENZYLAMINOPURINE (BAP) AND MICROPLANT POPULATION ON MICROTUBERISATION IN POTATO (*SOLANUM TUBEROSUM* L.)

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Abstract

Two experiments were conducted to produce microtuber in a potato cv. Diamant using two levels of BAP (5.0 and 7.5 mg/l) with a fixed dose of sucrose (8%). Three plant population (10, 20 and 30) and three age group of microplants (20, 30 and 40 days) were used in the experiments. The maximum number of microtubers and weight of microtubers per flask were 26.17 and 3432.31 mg when 30 plants were cultured with 7.5 mg/l BAP. The mean weight of each microtuber was the highest for 5 mg/l BAP and 10 plant population (215.50 mg) against the minimum of 129.11 mg with the same BAP level and 30 plant population. The application of BAP @ 5.0 mg/l with 10 plant population produced the maximum effective size (100-200 mg plus >200 mg) and microtuber (87.05%). Twenty days old microplants with 7.5 mg/l BA produced the maximum number of microtubers and weight of microtubers per flask (7.33 and 1332.0 mg respectively). The maximum mean weight was 190.4 mg with 5 mg/l BAP and 20 days old microplants compared to the minimum 124.7 mg with 7.5 mg/l BAP and 40 days old microplants. BAP @ 5 mg/l with 20 days old microplants produced the maximum effective size (100-200 mg plus >200 mg) and microtuber (83.57%). The maximum desirable size microtuber (>100 mg) could be obtained by using 10 plantlets per flask with 5 mg/l BAP (87.05%) or 20 days old plantlets with 5 mg/l BAP (83.57%).

Introduction

Potato is a cash crop in Bangladesh. Seed health is one of the important factors for development of this sector. Virus free seed potato tuber is the major concern. Production of seed potato is a highly technical matter. Few years back, clonal system was followed for the production of seed potato. With the development of tissue culture technology, the only method of producing virus-free seed potatoes, the clonal system has been replaced. At present about 38 tissue culture laboratories are in operation in the country and most of the laboratories are producing seed potatoes with microplants. None of them producing microtubers in spite of lot of advantages (easy to handle, store, planting, etc) due to lack of suitable protocols. Microtubers are produced *in vitro* on complete plantlets or on plant organs by changing the nutrient media and /or the external conditions. *In vitro* produced microtubers are generally weight to 0.2 g per tuber or less (Hussey and Stacey, 1984; Garner and Blake, 1989). Usually a whole microplant produced one microtuber, occasionally two.

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A number of factors like photoperiod, light intensity, temperature, nitrogen level in media, debudding, sucrose concentration, physiological age of microplants in association with growth promotors or retardants (Menzel 1981; Leclerc *et al.,* 1994; Dobranszki and Mandi, 1993; KabSeog, 2004) are responsible for *in vitro* tuberisation. Among the growth promotors, BAP stimulates microtuberisation very effectively (Hussey and Stacey, 1984). Generally, 5.0 to 10 mg/l BAP are used for microtuber production in potato, though 2.0 mg/l gave comparative better yield performance to 5 mg/l BAP. However, the production of microtubers can be accelerated by modifying the plant population in culture. According to CIP protocol (Tovar, 1985), 30 single nodes are usually used in a 250 ml Erlenmeyer flask in order to harvest 27 microtubers but the average size was not promising. On the other hand, age of microplants is also an important factor which influenced the production of microtubers in potato. Hence, the study was undertaken to enhance microtuber production of the potato cv. Diamant using different factors like BAP, plant population and age of microplants.

Materials and Methods

The *in vitro* ready stocks of microplants of the potato cv. Diamant (Dutch origin) were used in two seperate experiment. In the first experiment, two levels of benzylaminopurine (BAP) at 5.0 and 7.5 mg/l and three levels of plant population (10, 20 and 30 nodal cuttings per 200 ml flask) and in the second experiment the above two levels of BAP and three age group of microplants (20, 30 and 40 days old) were used. In the second experiment, five microplants of 5-6 cm long excluding the roots were used in each 200 ml flask. In both the experiments the plantlets were developed *in vitro* through liquid culture as described by Estrada *et al.* (1986). The culture media were replaced to tuberisation media having MS basic salts supplemented with BAP as per treatments, 8% sucrose and in the second experiment, liquid culture media for growth of microplants were replaced in tuberisation media as per treatments.

Media composition for plantlet growth in liquid shaken culture media was as described by Dodds *et al.* (1988). The pH of all media was adjusted to 5.8 and the media were autoclaved at 15 psi and 121^{0}C temperature for 20 minutes. Forty millilitre culture medium was poured in each culture jar. The culture jars for plantlet growth were incubated under 3000 lux light intensity for 16 hrs daily and at 22^{0}C temperature. Tuber formation was done under complete dark condition having a temperature of 19±1^{0}C. The experiment was laid out in a complete randomised design (CRD). The microtubers were harvested 90 days after the addition of tuberisation media. Hussey and Stacey (1984) harvested microtuber 12-15 weeks after the addition of tuberisation media. The microtubers were harvested under the laminar air flow cabinet and the individual tuber weight as per treatments was measured and the tubers were graded into more than 200, 100-200 and less than 100 mg size by number. Data on microtuber production and yield were recorded, analysed and the means were separated using LSD.

Results and Discussion

Days to tuber initiation: The number of days required for tuber initiation due to BAP level and plant population was not significantly different. However, tuberization was delayed by 7.50 days when 7.5 mg/l BAP was used with 30 plant population where it was earlier by same level of BAP with 20 plant population. It appeared that plant population in relation to BAP did not affect tuberization (Table 1), whereas tuberisation was affected due to age of microplants. The

30 days old microplants cultured with 7.5 mg/l BAP took the minimum of 6.16 days for tuberisation which was statistically similar to 40 days old microplants with 5.0 mg/l (Table 2).

The dominating role of nitrogen in plant growth and tuber formation of potato plant has been emphasised by several workers (Okazawa, 1967; Palmer and Smith, 1970). As regularity factor for tuberisation, its form and concentration are highly significant. But both very low or very high levels of nitrogen are inhibitory, though high level is more deletorius than low level (Garner and Blake, 1989). In the present study, 60 Mm/L the N was used with 5.0 or 7.5 mg/l BAP which supplied the required amount of nitrogen and thus did not affect initiation of microtubers in culture. However, for tuber initiation it required exogenous supply of nitrogen coupled with different stimulating agents like, IAA, 2, 4-D, NAA, BAP, etc. According to Hussey and Stacey (1984), Leclerc *et al.* (1994) and Shibli *et al.* (2001) that tuber initiation and growth in potato is control by a balance between inhibitors and promoting substances, which is indicative to antigibberellins like cycocil, coumarin, abscisic acid, jasmonoid, cytokinin, triiodobenzoic acid, meleic hydrazide, etc. (Choi *et al.,* 1993; Paet and Zamora, 1994; Hossain and Sultana, 1998; Silva *et al.,* 2001).

No. of tubers per flask: The number of microtubers per culture jar varied significantly due to plant population in flask and BAP levels. It ranged from 6.16-26.17. The number of tuber per flask increased with increasing plant population. BAP at 5 mg/l with population density of 10 produced only 6.16 microtubers per flask which increased to 25.33 at plant density of 30. Similarly, 7.5 mg/l BAP with plant population of 10 produced only 6.83 microtuber, which increased to 26.17 at plant density 30 (Table 1). The number of tubers per plants did not vary significantly due to age of micro plants. which ranged from 5.0-7.33. The younger plants (20 days old) produced the maximum microtubers per flask which gradually decreased with increasing age of microplants. The 30 days old microplants cultured in 50 mg/l BAP had the minimum number of microtubers per flask (5.00) closely followed by 40 days old microplants with 7.5 mg/l BAP (Table 2).

Plant population is considered as an important factor in producing more number of microtubers from a single culture jar as indicated by Jimenez *et al.* (1999). In general, more the number of plant in culture, more the number of microtubers. However, Hossain and Sultana (1995) obtained heavier microtubers from lower plant population, though high plant population increasing the number of microtubers, which was in agreement with the findings of the present investigation. Most of the workers used different plant population for improving microtuber production programme. But Khomyak *et al.* (1998) used different plant population with different volume of culture media to improve the microtuber production while Forti *et al.* (1992) used single node explants at different plant densities for microtuberisation in a better way.

Weight of microtuber per flask: The weight of microtuber per flask differed significantly due to plant density and BAP levels used in the culture media (Table 1). The highest weight of microtuber per flask was 3132.31 mg/l with 7.5 mg/l BAP and a plant population of 30 which was statistically similar to 3205.21 mg with 5.0 mg/l BAP and a plant population of 30 (Table 1). The trend was almost similar for population density of 10 and 20 with 5.0 and 7.5 mg/l BAP, respectively. The maximum weight was 1332 mg for 20 days old microplants cultured in 5 mg/l BAP which was statistically similar to 7.5 mg/l BAP (1288.0 mg). The minimum weight of

microtuber was 662.00 mg with 40 days microplant in 7.5 mg/l BAP. The weight of microtuber decreased gradually with increasing age of microtuber (Table 2). It indicates that younger microplants are more suitable for microtuber production.

The physiological age of the mother tuber act on tuberization either directly or indirectly mediating changes in hormone concentrations (Vander Zaag and Van Loon, 1987; Burton, 1989; Ewing and Struik, 1992). Most authors agree that the yield of physiologically older seed is markedly higher than that of younger seed if harvested prematurely (Bus and Schepers, 1978; Bean and Allen, 1980). But several authors have found lower yields with physiologically old seed than with young seed (Reust, 1982). Other researchers found almost no effect of physiological age on yield (Bus and Schepers, 1978). Moll (1985) found that the yield of early cultivars grown from old seed was lower than their yield when grown from young seed. The physiological age of mother tubers used as a source of material influenced kinetin-induced *in vitro* tuberization. Tuberization significantly increased with physiologically young plant (Villafranca *et al.,* 1998). Tuber inducing activity was detected in leaves and old tubers using single-node and stem. Akita and Takayama (1988) found greatest microtuber by using *in vitro* plantlet of 4 weeks old in continuous dark. Similar result was observed by Rosell *et al.* (1987).

Mean weight of each microtuber: The mean weight of microtuber varied significantly due to the treatment combination of population density and BAP levels. The lower the plant population the higher the mean weight of microtuber per flask. The maximum mean weight of each microtuber was 215.50 mg under 5.0 mg/l BAP and a plant population of 10 per flask which reduced gradually to 129.11 mg with a plant density of 30 (Table 1). Similarly, the mean weight of microtuber under 7.5 mg/l BAP with a plant population of 10 was 200.21 mg which gradually reduced to 132.81 mg under a plant population of 30 (Table 1). The mean weight of each microtuber decreased gradually with microplant age. However, the maximum was 190.40 mg for 20 days old microplants cultured with 50 mg/l BAP while the minimum was 124.7 mg for 40 days old microplants with 7.5 mg/l BAP (Table 2).

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Tuber grading

The size distribution of microtuber in number percentage of >200 mg varied significantly due to combined treatment of BAP levels and plant population (Table 2). The maximum percentage of > 200 mg size microtuber was 55.18 under 5.0 mg/l BAP with a plant density of

10 which was statistically similar to 48.89% under 7.5 mg/l BAP with the same population (Table 1). On the other hand, the maximum percentage of >200 mg size microtuber in relation to BAP levels and plant age was 49.82 under 5.0 mg/l BAP and 20 days old microplants which was statistically similar to 7.5 mg/l BAP levels and 20 days old microplants (45.11%). The minimum percentage of >200 mg size microtuber was produced when 7.5 mg/l BAP was used in culture media to produce microtuber in 40 days old microplants (28.89) (Table 2).

Table 1. Combined effect of BAP and plant population on the production and size of microtubers of potato cv. Diamant

Treatment		Days to tuber initiation	No. of microtuber per flask	Wt of microtuber per flask (mg)	Mean micro tuber wt. (mg)	Grades of tubers (mg) by no. (%)		
BAP level (mg/l)	Plant population					>200	100-200	<100
5.0	10	6.66	6.16	1319.02	215.50	55.18	31.87	12.96
	20	6.66	14.50	2541.21	178.12	48.75	26.77	23.30
	30	7.00	25.33	3205.21	129.11	23.07	41.83	35.09
7.5	10	6.50	6.83	1351.03	200.21	48.89	26.75	26.75
	20	6.00	16.11	2535.12	159.81	33.22	40.62	26.16
	30	7.50	26.17	3432.31	132.81	19.67	43.40	36.94
LSD 0.05		ns	4.32	546.12	25.18	6.60	7.26	8.48

ns = non-significant

Table 2. Combined effect of BAP and plant age on the production and size of microtuber of the potato cv. Diamant

Treatment		Days to tuber induction	No. of micro tubers per flask	Wt. of micro tuber per flask (mg)	Mean micro tuber wt. (mg)	Grades of microtuber (mg) by no. (%)		
BAP level (mg/l)	Plant age (day)					>200	100-200	<100
5.0	20	6.33	7.00	1332.00	190.40	49.82	33.75	16.43
	30	11.83	5.00	813.30	164.80	33.93	40.48	25.6
	40	7.83	5.66	890.20	157.40	41.03	35.87	23.1
7.5	20	7.33	7.33	1288.00	174.90	45.11	29.76	25.13
	30	6.16	6.66	1094.00	165.00	42.38	33.06	24.56
	40	11.33	5.33	662.00	124.70	28.89	34.17	36.94
LSD 0.05		1.83	1.20	205.60	17.16	6.52	5.00	9.73

In case of 100-200 mg size microtuber, it was almost reverse to >200 mg size grade except 5.0 mg/l BAP and plant population of 10 and 20 and 7.5 mg/l BAP and plant population 10. The minimum percentage of microtuber was 26.75 under 7.5 mg/l BAP and plant population of 10 and the maximum was 43.40 under 7.5 mg/l BAP and a plant population of 30. The maximum percentage of effective size microtuber (>200 mg plus 100-200 mg) was 87.05 when 5.0 mg/l BAP was used to produce microtuber in 10 microplants per flask.

Regarding <100 mg size microtuber irrespective of BAP levels (5.0 or 7.5 mg/l) the percentage of microtuber increased with increasing plant age. It was 12.96% under 5.0 mg/l BAP and plant population of 10 which increased to 35.09% at plant population of 30 with 7.5 mg/l BAP. It was 26.75% with 7.5 mg/l BAP and plant population of 10 which increased to 36.94 with plant population of 30 (Table 2). The treatment combination of 5 mg/l BAP and plant age of 30 days produced the maximum percentage of 100-200 mg size microtuber

(40.48%), closely followed by the same BAP level and a plant age of 40 days (35.87%). The minimum percentage of 100-200 size microtuber was 29.76 when 7.5 mg/l BAP was used in culture media to produce microtuber in 20 days old microplant. Irrespective of BAP levels 20 day old microplants produced minimum percentages of 100-200 mg size microtuber which gradually increased with increasing plant ages. The maximum percentage of effective size microtuber (>200 mg plus 100-200 mg) was produced by 5.0 mg/l BAP and 20 days old microplant (83.57%).

The combined treatment of 7.5 mg/l BAP and 40 day plant age produced the maximum percentage of <100 mg size microtuber (36.94%) and the minimum was 16.43% under 5.0 mg/l BAP and 20 day plant age. The other combined treatments varied in between 23.10-25.60%. At both the levels of 5.0 and 7.5 mg/l BAP, the 20 and 30 day plant ages produced almost similar percentages of microtuber (Table 2).

Conclusion

From the above results it may be concluded that culture of 10 plantlets per flask with 5 mg/l BAP (87.05%) or 20 days old plantlets with 5 mg/l BAP (83.57%) for microtuber production could give the maximum desirable size microtuber (>100 mg).

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RESPONSE OF RICE TO POTASSIUM FERTILIZER AND ITS APPARENT BALANCE IN OLD BRAHMAPUTRA FLOOD PLAIN AND TERRACE SOIL

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Abstract

A field study on the effect of K on Boro and T. aman rice was conducted at Bangladesh Agricultural University, Mymensingh and BADC Farm, Madhupur, Tangail during 2007 to 2009. The objectives were to see the response of rice to K application and to determine the optimum K dose and K balance for better understanding of K management in wet land rice. Six levels of potassium viz. 0, 30, 60, 90, 120 and 150 kg K ha^{-1} were tested. The trials were laid out in randomized block design (RCBD) with three replications. Nitrogen, P and S were applied as blanked dose. Rice yield increased with K application in both the seasons at both the locations. The response of rice to applied K followed quadratic trend. The economic optimum rate of potassium for the two locations varied from 90 to 125 kg K ha^{-1} for T. aman rice and 96 to 141 kg K ha^{-1} for Boro rice. The K uptake was higher in Boro rice than in T. aman rice. The apparent K recovery gradually decreased with increasing the rate of K application. The highest K (61 to 95%) was recovered from the treatment of 30 kg K ha^{-1}. The negative K balance was found up to 150 kg K ha^{-1} with diminishing magnitude.

Introduction

Potassium nutrition of agricultural crops in Bangladesh depends mainly on soil K resources and K fertilizer imports. The consumption of K by rice is highest among the essential nutrient elements as exerts a balancing effect on both N and P. VonUexkull (1978) reported that modern rice varieties removed much higher K than P and some times more than N.

Farmers in Bangladesh use extremely low amount of K and sometimes no K fertilizer for rice cultivation. The necessity of K fertilizer in Bangladesh agriculture, practically for rice cultivation is often questioned by many farmers and policy makers. This is mainly because of that the use of K does not always show visible changes in vegetative growth of rice as often observed with the use of N. Moreover, deficiency symptoms of K in rice are less conspicuous than N and S.

Intensive cropping and use of modern rice verities for high yield caused heavy depletion of K in soil, particularly in absence of K application (Tiwari, 1985). Mohanty and Mondal (1989) reported a negative K balance in rice systems at many sites in India. The present experiments were conducted on Boro-T. aman rice cropping system in Old Brahmaputra Flood Plain and Terrace soils to investigate the response of rice to K application and K balance.

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Materials and Methods

Four field trials were conducted at BAU farm, Mymensingh and BADC farm, Madhupur, Tangail during 2007 to 2009. BAU farm soils of fall under Sonatola series and that of BADC farm under Noadda series. The texture of the soils was silt loam to clay loam. The pH was 4.83 to 6.53 having organic matter content of 1.89 to 2.65% and exchangeable K of 0.087 to 0.097 cmol kg^{-1} soil. CEC, Available P, S, total N and CEC were higher in BADC farm soil. The exchangeable Ca and Mg were higher in BAU farm soils than BADC farm soils (Table 1). Mica was higher in BADC farm soil (33-35%) while vermiculite was higher in BAU farm soil (14-18%) (Table1). The trials were laid in randomized block design (RCBD) with 3 replications. There were six levels of K viz. 0, 30, 60, 90, 120 and 150 kg ha^{-1}. Nitrogen, P and S were applied as blanket dose on soil test. The doses for T. aman rice were 67N: 14P: 5S kg ha^{-1} for BAU farm soil and only 60 kg Nha^{-1} for BADC farm soil. The doses for boro rice were 189N: 36P: 10S kg $ha^{-1}$for BAU farm soil and only 167 kg Nha^{-1} for BADC farm soil. The status of P and S in BADC farm soil was high hence not applied in either of the crops. The test rice varieties were BRRI dhan 41 in T. aman and BRRI dhan 29 in Boro seasons. The unit plot size was 5m × 4m. Two healthy seedlings/hill were transplanted at a spacing of 20 cm × 20 cm. Full doses of P and S was applied at the time of final land preparation. Nitrogen was applied in 3 equal splits; at 12 days after transplantation, at active tillering stage and rest at panicle initiation stage. The T. aman rice was transplanted in the 3rd week of July and Boro rice in the 2nd week of February. Plant protection measures and cultural practices were followed throughout the growing period. The crops were harvested at maturity of rice from a 5 m × 1m area in each plot. The grain yield was recorded at 14% moisture content on an oven dry basis and it was expressed in t ha^{-1}. Mean separation was done by Duncan's multiple range tests. Regression analysis was done between K rate and yield of rice. Maximum K rate and the economic optimum rate of K for rice were estimated following the equation of Gomez and Gomez (1984) as;

$$K\max = -\frac{b}{2c}$$

Where b and c are the numerical constants in quadratic equations of response functions,

$$Kopt = \frac{(\frac{pf}{py} - b)}{2c}$$

Where P_f and P_y are prices of K (Tk.35/kg), rice grain (Tk.20/kg), respectively.
Grain and straw samples were dried in an oven at 70°C for 72 hrs and ground in Willey mill. The samples were analyzed for K content following method of Yoshida *et al.* (1976) and K uptake was calculated.

Agronomic K use efficiency was calculated using the formula;

$$\text{Agronomic K use efficiency (kg grain per kg)} = \frac{(Yk\text{-}Yo)\ kg\ ha^{-1}}{K\ applied\ (kg\ ha^{-1})}$$

Where, Y_k = Grain yield in K treated plots ($kgha^{-1}$), Y_0 = Grain yield in K controlled plots (kg ha^{-1})

Table 1. Chemical and mineralogical properties of BAU and BADC farm soils (0-15 cm)

Soils	Chemical properties										
	pH	Organic carbon (%)	Exchangeable K(cmol kg^{-1} soil)	Calcium (cmol kg^{-1} soil)	Magnesium (cmol kg^{-1} soil)	CEC(cmol kg^{-1} soil)	Potassium saturation (%)	Total N (%)	Phosphorus (mg kg^{-1} soil)	Sulfur (mg kg^{-1} soil)	
BAU	6.72	0.77	0.087	4.00	0.44	11.12	1.92	0.06	2.47	20.49	
BADC	4.83	0.87	0.097	1.50	0.17	9.50	5.49	0.092	29.05	26.22	
	Mineralogical properties										
Soils	Mica	Vermiculite	Chloride	Kaolinite	Vermiculite Smectite	Vermiculite-Smectite	Interstratified Mica-Chloride	Quartz	Goethite	Lepidocrrocite	Feldapar
BAU	24.00	18.00	17.00	7.00	18.00	-	6.00	3.00	2.00	4.00	1.00
BADC	33.00	-	6.00	19.00	7.00	26.00	-	7.00	1.00	-	1.00

Rain and irrigation water was also collected during the growing crop period of crop and analyzed for K. Percolation water (L m^{-2}) was calculated using the formula $Q= - K_W AT. \Delta\Psi_h/\Delta z$ given by Hanks and Ashcroft (1960).

Where,

Q = Quantity of water

K_w = Hydraulic conductivity

A = area

T = Time

h = Difference in hydraulic potential and

Z = Difference between two points taking 0 to downward as negative.

The hydraulic potential was again calculated by adding the component potentials as $\Psi_h= \Psi_m+ \Psi_p+ \Psi_z$ where h, m, p, and z represent hydraulic, metric, pressure and gravitational potentials. Negative Q was considered as downward movement of water.

Water balance (Input minus out put) was made fortnightly for a period of two years during T.aman and Boro seasons using simple equation; Water balance = Input – output

Input = Rainfall + irrigation + initial soil content

Output = ET + percolation / drainage losses

Apparent K recovery was calculated. After 2 years, apparent K balance was estimated from K uptake and leaching loss data. The mean apparent K balance was calculated using the following simple equation;

$$Ka = (Kf + Kr + Ki) - (Kupt + Kl)$$

where,

Ka= apparent K balance (kgha^{-1})
Kf= K added through fertilizer (kgha^{-1})
Kr= K added through rainfall (kgha^{-1})
Ki = K added through irrigation (kgha^{-1})
Kupt= K uptake by crop (kgha^{-1})
Kl = K lost through leaching (kgha^{-1})

Results and Discussion

Grain yield: The initial K status of BAU soil (0.087 cmol kg^{-1} soils) was below the critical limit of 0.12 cmol kg^{-1} as suggested by BARC (2005). Application of 30 kg K ha^{-1} in this soil did not significantly increase the yields over the control in 2007. Sixty kg K ha^{-1} increased the grain yield over 30 kg K ha^{-1} but it was significant only in 2007 (Fig.1). Application of K up to 90 kg ha^{-1} showed significant increase in both years over 60 kg K ha^{-1}. Further increasing the K rate from 120 to 150 kg ha^{-1} no significant increase in grain yields was noticed over 90 kg K ha^{-1}. In BADC farm soil, 60 kg K ha^{-1} significantly increased the grain yield over lower doses. The yield increase due to successive increase in K levels from 90 to 150 kg ha^{-1} was not significant over 60 kg K ha^{-1}. In both years, BAU farm soil produced a significant yield increase from 60 kg K ha^{-1} to 120 kg K ha^{-1} whereas the grain yields being statistically identical for 90 to150 kg K ha^{-1}. In boro season, the grain yield progressively increased up to 120 kg K ha^{-1} and

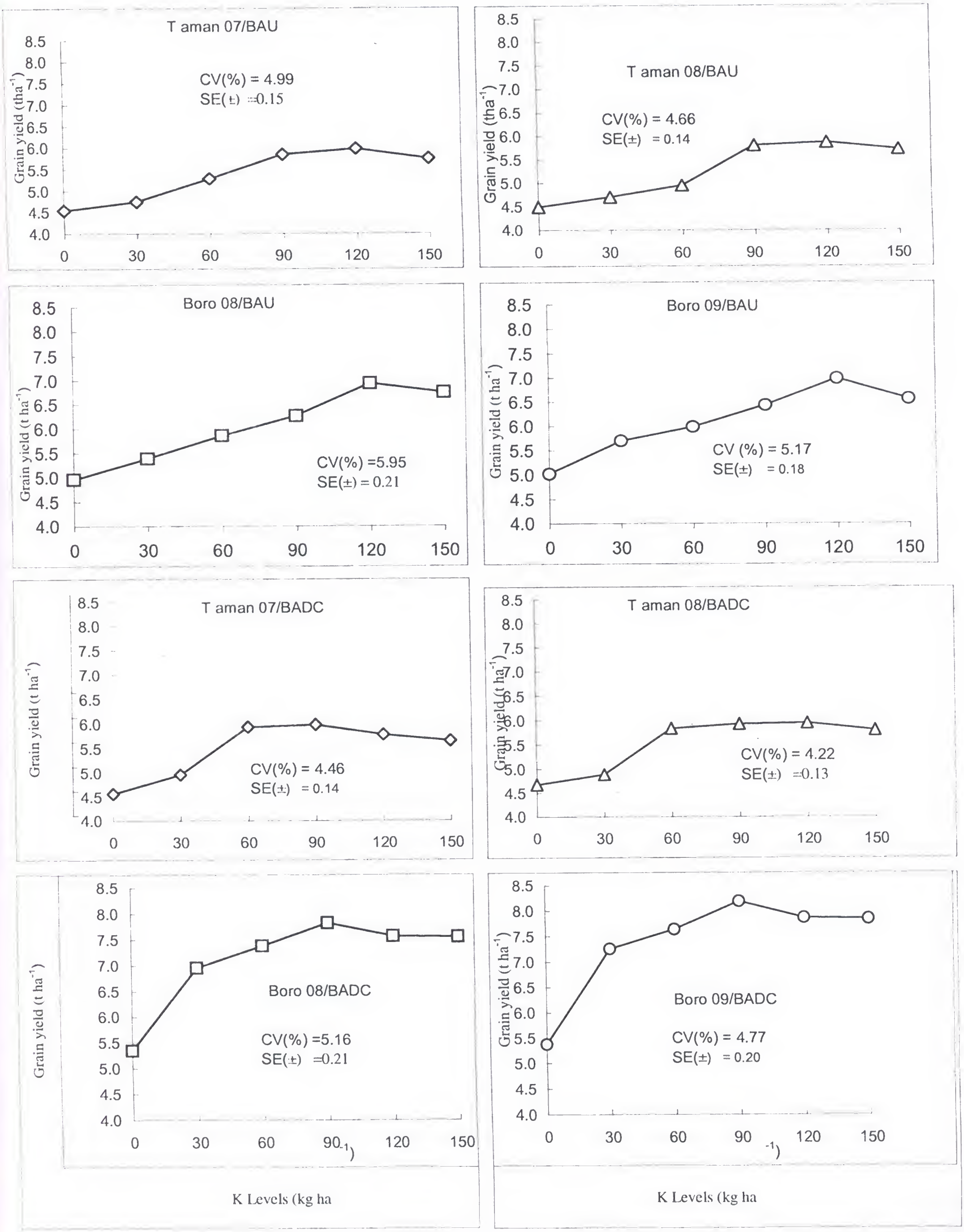

Fig. 1. Effects of K on grain yield of T. aman and Boro rice at BAU and BADC farm

thereafter, no increase was noticed in BAU farm (Fig. 1). Grain yield of BADC farm soil was significantly influenced by increased levels of K up to 60 kg ha^{-1} (Fig. 1). Ninety kg K ha^{-1} showed the best performance in producing grain yield over other treatments although it was statistically identical to 60, 120 and 150 kg K ha^{-1}(Fig. 1).Soils of BAU and BADC farms showed remarkable variation in mineralogy, fate of K and K fertility (Table1). BAU farm soil contained vermiculite. Potassium in this soil (native and added) remained mainly in non-exchangeable form as a consequence the exchangeable K, K release capacity and solution K was lower. Parvin *et al.* (2007) worked with similar soil and obtained results are in agreement with the results. The dominant mineral in BADC farm soil was mica and most of its K remained in exchange form. The K release capacity, solution K as well as K fertility of this soil was higher than BAU farm soils. Because of this higher K fertility of BADC farm soil, it required lesser amount of fertilizer compared to BAU farm soil for producing higher yield. Application of K increased the rice yield consistently up to 120 $kgha^{-1}$ of applied K (Saleque *et al.*, 1998). Singh and Patirum (1987) reported 100 kg K/ha for optimum and 187 kg Kha^{-1} for maximum for rice yields in Meghalaya, India. Ahsan *et al.* (1997) tested 5 levels of K (0, 30, 60, 90 and 120 $kgha^{-1}$) and reported that rice yield was increased with K fertilizer application in both dry and wet seasons. A regression analysis showed that at both soils, rice responded quadratically to K application in terms of grain yield (Fig. 2).

The quadratic functional relationship between K application and grain yield in T. aman and Boro rice was significant with coefficient determination of 0.91 to 0.95. A quadratic response of rice to K fertilizer was also reported in India by Singh and Patirum (1987).

K maximum and K optimum: The maximum dose and economic optimum dose of K calculated from the response equation (Fig.2 & Table 2) showed that the predicted maximum rate of K varied from 104 $kgha^{-1}$ to 167 $kgha^{-1}$ and economic optimum K dose varied from 92 $kgha^{-1}$ to 141 $kgha^{-1}$ in both soils. The values were much higher than the BARC (2005) recommended dose of K for that area. Singh and Patirum (1987) reported that 100 kg Kha^{-1} for optimum and 187 kg Kha^{-1} for maximum rice yield in Meghalaya, India.

Table 2. K maximum and K optimum for T. aman and Boro rice

Locations	K maximum (kg ha^{-1})		K optimum (kg ha^{-1})	
	T. aman	Boro	T. aman	Boro
BAU farm	153	167	126	141
BADC farm	104	107	92	96

K uptake by rice: In T. aman season, K uptake varied from 94.18 to 153.27 kg ha^{-1} and 76.95 to 139.54 kg ha^{-1} in 2007 and 2008, respectively at BAU farm soil. In BADC farm soil, the K uptake by T. aman during 2007 to 2008 followed almost the similar trend as in BAU farm soil. Uptake of K by Boro rice was similar to K uptake by T. aman rice in both soils. Potassium uptake significantly increased with increasing levels of K in both soils and seasons leading to higher straw yield coupled with grain yield (Fig. 3). The K concentration in grain and straw of T. aman (BRRI dhan 41) and Boro (BRRIdhan 29) was almost similar. But the straw yield of T. aman was higher than Boro. As a result of which, the uptake was higher in T. aman. In boro season, nutrient uptake was lower in BADC farm compared to BAU farm because of higher yield. The findings are in agreement with the results of Devendra *et al.* (1999), Hu *et al.* (2004) and Pattanayak *et al.* (2008).

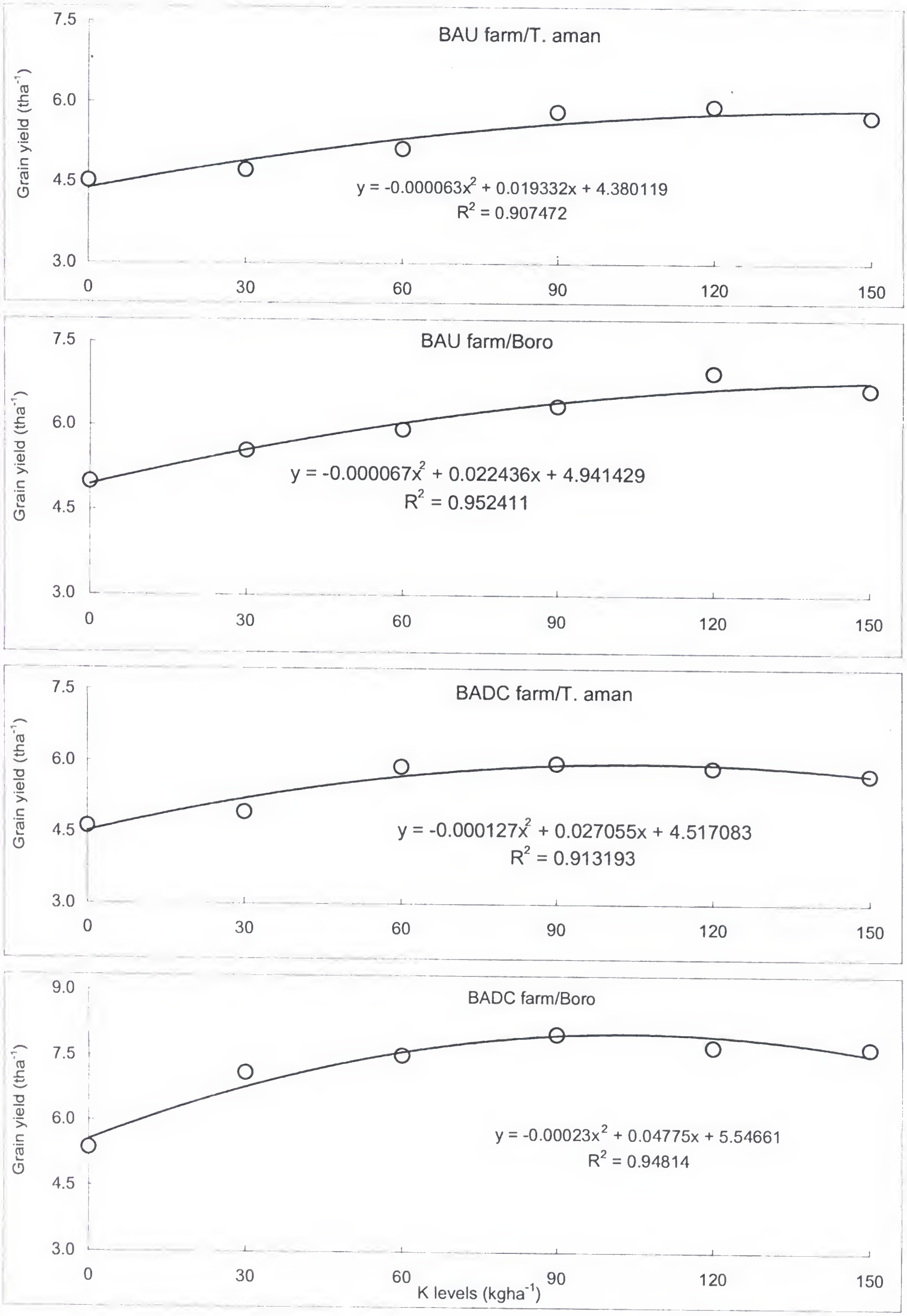

Fig.2. Response of rice to potassium application

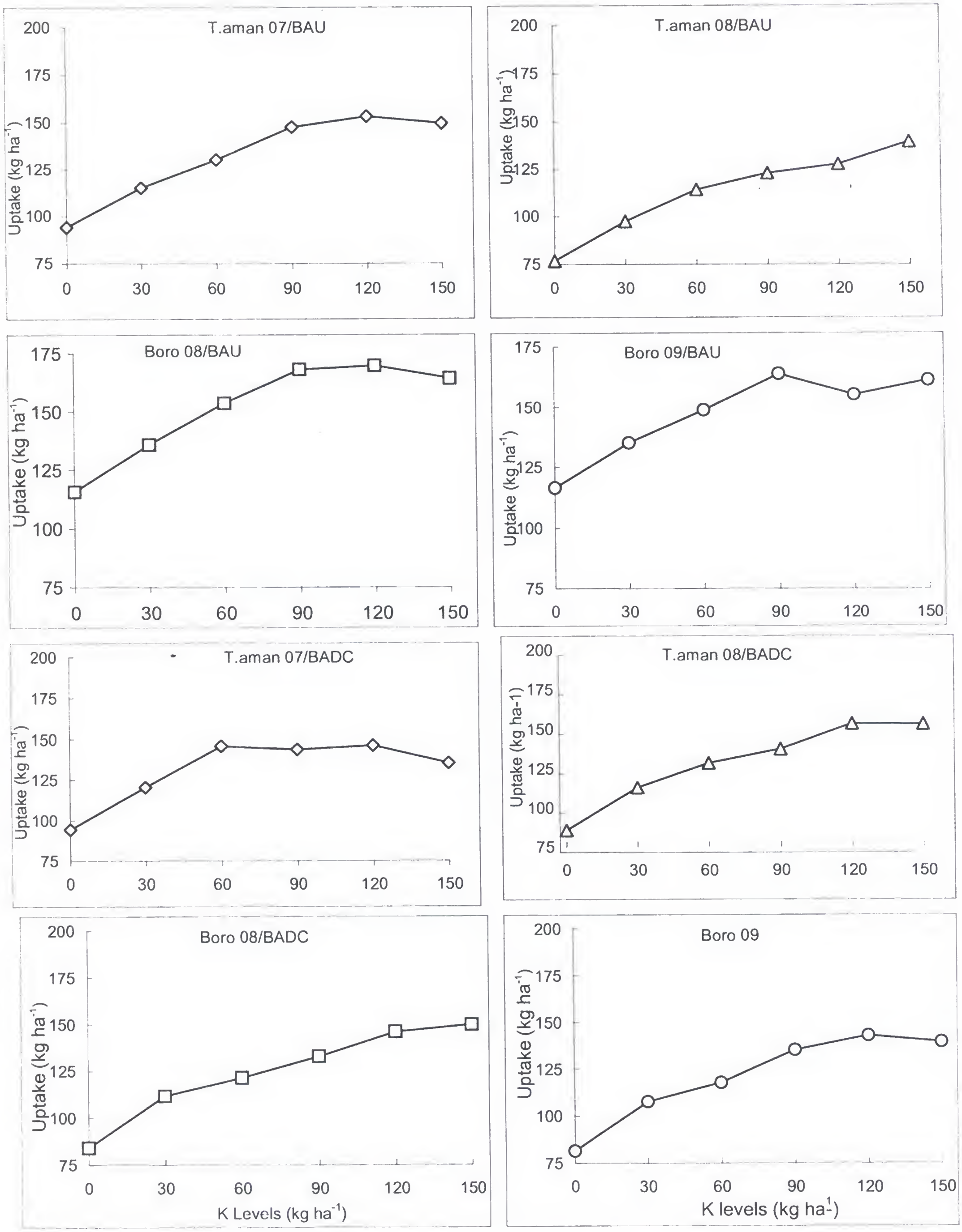

Fig. 3. Effects of K on K uptake by T. aman and Boro rice at BAU and BADC farm

Agronomic potassium use efficiency: In T. aman season, the agronomic potassium use efficiency increased up to 60 kg K ha^{-1} in BAU farm soil and thereafter, the K use efficiency gradually decreased with increasing K application upto 150 kg K ha^{-1} (Table 3). The variation in K use efficiency between years was very negligible in a particular soil. The K use efficiency in BADC farm soil and BAU farm soil was nearly or almost similar and its trend between the soils for different levels of K was also similar. In general, the K use efficiency of Boro rice grown in BAU and BADC farms was highest at 30 kg ha^{-1} level of K in all years (Table 3). Between the two soils, the K use efficiency in BADC farm soil was higher than BAU farm soil. The results were supported by the findings of Saleque *et al.* (1998).

Apparent recovery percent of potassium from applied potassium: The percent apparent K recovery (Kilogram K uptake per kilogram of added K) exhibited decreasing trend with increasing applied K levels in both the soils for both T. aman and Boro season (Tables 3). In general, the higher percent apparent K recovery was noticed in the 30 kg K ha^{-1} receiving plots compared to other treated plots. In T. aman season, the percent K recovery varied from 25.11 to 121.32 % in BAU farm soils and 27.54 to 90.39 % in BADC farm soils. In Boro season, it varied from 29.70 to 81.27 % in BAU farm soils and 22.82 to 94.82 % in BADC farm soils. In T. aman season, the highest apparent K recovery was 121.32 % in K_{30} treated plot in BAU farm soil in 2007 where the lowest was 25.11 % in K_{150} treated plot in the same soil in 2008. Similar type of results was found by Vipin and Prasad (2003), Hu (2004) and Mazid *et al.* (2008).

Potassium input through rain water: Two rain samplers were installed besides the experimental sites. One was at BAU farm and another one at BADC farm. Rain water was collected after each rain event and immediately analyzed for K. Data on rainfall amount, K concentration in rain water and input of K through rain water has been presented in Table 4.

During the T. aman season in 2007 and 2008 rainfall was 702.30 mm and 737.00 mm at BAU farm and 504.15 mm and 560.76 mm in BADC farm, respectively (Table 4).The K concentration in rain water was 0.34 to 0.35 mg L^{-1} at BAU farm while it was 0.53 to 0.54 mg L^{-1} at BADC farm (Table 4). The amount of added K from rain water was 2.46 & 2.51 kg ha^{-1} at BAU farm, and 2.79 & 2.97 kg ha^{-1} at BADC farm in T. aman season of 2007 and 2008, respectively (Table 4).

During the Boro season, the amount of rainfall was 327.70 and 392.80 mm in BAU farm, and 274.55 and 208.90 mm in BADC farm in 2008 and 2009, respectively (Table 4). The concentration of K in rain water was 0.96 and 0.97 mg L^{-1} at BAU farm while it was 1.02 and 1.03 mg L^{-1} at BADC farm in 2008 and 2009, respectively (Table 4). The addition of K through rain water was 3.15 to 3.77 kg ha^{-1} at BAU farm but it was 2.15 to2.80 kg ha^{-1} at BADC farm (Table 4). In remote areas from sea the concentration in rain water is mainly influenced by the dust particles emitted to the air from soil by wind. Rain events and amount of rainfall also remarkably influence the concentration. In boro season the amount and events of rainfall was very low but the amount of dust particle was very high which resulted the obtained higher concentration in both locations. The obtained lower K concentration In T. aman season was due to dilution by higher rainfall.

Potassium input through irrigation water: Irrigation water was applied to the experimental plots from deep tube well (DTW) near the experimental sites at both farms. The amount of irrigation water was measured by using V-Notch weir method (Khurmi, 1987). Water samples were

Table 3. Effects of K on agronomic use efficiency and apparent recovery of T. Aman and Boro rice at BAU and BADC farm

K levels ($kgha^{-1}$)	Agronomic use efficiency (kg grain per kg K)								Apparent K recovery (%)							
	T. aman				Boro				T. aman				Boro			
	BAU		BADC		BAU		BADC		BAU		BADC		BAU		BADC	
	2007	2008	2007	2008	2008	2009	2008	2009	2007	2008	2007	2008	2008	2009	2008	2009
0	6.78	6.77	13.00	7.11	14.33	22.67	53.67	62.67	-	-	-	-	-	-	-	-
30	12.39	7.61	22.78	19.33	15.00	16.17	33.83	37.67	75.80	67.10	89.58	90.39	72.20	61.26	94.82	88.75
60	14.48	14.56	15.70	13.89	14.56	15.67	27.44	31.22	63.66	60.77	86.45	71.34	64.73	54.18	61.93	61.49
90	12.00	11.47	10.11	10.58	16.50	16.33	18.50	20.75	61.02	50.55	57.48	57.16	60.12	52.27	54.00	60.19
120	8.04	8.18	7.22	7.51	11.93	10.27	14.67	16.47	50.80	42.63	43.37	56.65	46.08	32.02	51.67	51.90
150	6.98	6.88	13.60	7.21	14.53	22.97	53.87	62.87	38.01	41.50	24.54	47.22	33.30	30.01	43.85	39.04

collected during each irrigation and analyzed for K. Data on the amount of irrigation water, K concentration in irrigation water and addition of K through irrigation water have been presented in Table 4.

In T. aman season, little amount of irrigation water was required compared to Boro season because of higher rainfall of 703 to 737 mm at BAU farm and 504 to 560 mm at BADC farm. During this season, an amount of 173 to 210 mm irrigation water was applied at BAU farm in different plots and years. But at BADC farm it varied from 143 to 160 mm. In Boro season, the irrigation water varied from 341 mm to 343 mm at BAU farm and a higher amount of 381 to 414 mm at BADC farm. The variation between the locations and years was mainly due to variation in amount and rain events.

The mean concentration of K in irrigation water was 1.60 mg L^{-1} at BAU farm while it was 1.80 mg L^{-1} at BADC farm in T. aman season. The addition of K was higher in Boro season than in T. aman season because of higher amount of irrigated water. The concentration of K in irrigation water and its addition in BADC farm was higher than BAU farm for higher irrigation mainly.

Potassium balance: Potassium balance was influenced remarkably due to application of K in both T. aman and Boro seasons of 2007 to 2009 at BAU and BADC farms. The balance was negative irrespective of K levels, seasons and soils (Table 5).

In T. aman season, a very small amount of 2.94 and 2.99 kg K ha^{-1} was added from rain and irrigation water, respectively to BAU farm soil. The total gain of K varied from 5.92 to 155.92 kg ha^{-1} depending on K levels. On the other hand, leaching loss of K with percolation water and crop uptake varied from 12.10 to 89.35 kg ha^{-1} and 84.73 to 144.36 kg ha^{-1}, respectively. As a consequence total loss of K was 96.83 to 233.71 kg ha^{-1}. The lowest and the highest gain and loss was in K_0 and K_{150} treated plots, respectively. As the total loss of K was much higher than the total gain, a considerable amount of K was lost from the native sources. The negative balance of K was almost constant upto 120 kg K ha^{-1} levels but at 150 kg K ha^{-1} the loss of native K was lower than others because the uptake by crop was less compared to 120 kg K ha^{-1}.

In BADC farm soil the input of K was 5.61 to 155.61 kg ha^{-1} irrespective of soils in two years where more than 2.88 and 2.73 kg K ha^{-1} was added from rain and irrigation water, respectively. The rest was added from fertilizer. Depending on the different levels of K, the leaching loss of K with percolation water varied from 6.59 to 89.59 kg ha^{-1} in BADC farm soil. The total loss gradually increased with increased levels of K but the rate of loss decreased. The negative balance of K showed an increasing trend up to 60 kg K ha^{-1} level and thereafter it did not change remarkably up to 150 kg K ha^{-1} level.

In Boro season, the input of K to BAU farm soil from rain (3.48 kg ha^{-1}) and irrigation water (5.51 kg ha^{-1}) during the Boro season was negligible although it was higher than the amount added in T. aman season. The leaching loss through percolation water increases with increasing K levels ranging from 5.69 to 66.19 kg ha^{-1}. The crop uptake was 115.26 to 165.84 kg K ha^{-1}. As such total output of K varied from 120.95 to 228.93 kg ha^{-1}. The higher total loss compared to total gain indicates that a considerable amount of K was lost from native source of soil. The maximum and minimum gain and loss was in 0 and 150 kg K ha^{-1} levels respectively. The crop uptake was higher than leaching loss. The negative balance of K varied from -69.94 to -111.96 kg K ha^{-1}. The negative balance of K decreased with increasing K up to 150 kg K ha^{-1}.

Table 4. Addition K through rainfall and irrigation water during the growing period of T. aman and Boro rice at BAU farm and BADC farm

Rice growing seasons	Rice growing years	Rainfall						Irrigation water					
		Amount (mm)		K conc. (mgL^{-1})		K added ($kgha^{-1}$)		Amount (mm)		K conc. (mgL^{-1})		K added ($kgha^{-1}$)	
		BAU	BADC	BAU	BADC	BAU	BADC	BAU	BADC	BAU	BADC	BAU	BADC
T. aman	2007	737.00	560.76	0.34	0.53	2.51	2.97	173.00	143.00	1.60	1.80	2.77	2.57
	2008	702.80	504.15	0.35	0.54	2.46	2.79	210.00	160.30	1.60	1.80	3.36	2.89
Boro	2008	327.70	274.55	0.96	1.02	3.15	2.80	341.08	380.77	1.61	1.81	5.49	6.89
	2009	392.80	208.90	0.97	1.03	3.77	2.15	342.90	413.66	1.61	1.81	5.52	7.48

Table 5. Mean balance of potassium (kg ha^{-1}) for T. aman and Boro rice at BAU and BADC farms (2007-2009)

K levels (kg/ha)	Input (kg/ha)				Output (kg/ha)			Balance (kg/ha)
	K from fertilizer	K from rainfall	K from irrigation	Total	Leaching loss	Crop uptake	Total	
T. aman season								
BAU farm								
0	0.00	2.94	2.99	5.92	12.10	84.73	96.83	-90.91
30	30.00	2.94	2.99	35.92	24.08	106.17	130.25	-94.33
60	60.00	2.94	2.99	65.92	38.00	122.06	160.06	-94.14
90	90.00	2.94	2.99	95.92	55.34	134.94	190.28	-94.36
120	120.00	2.94	2.99	125.92	79.44	140.79	220.22	-94.30
150	150.00	2.94	2.99	155.92	89.35	144.36	233.71	-77.79
BADC farm								
0	0.00	2.88	2.73	5.61	6.59	89.71	96.30	-90.61
30	30.00	2.88	2.73	35.61	24.96	116.70	141.66	106.05
60	60.00	2.88	2.73	65.61	36.05	137.04	173.09	107.09
90	90.00	2.88	2.73	95.61	53.56	141.29	194.85	-99.24
120	120.00	2.88	2.73	125.61	61.52	149.71	211.24	-85.63
150	150.00	2.88	2.73	155.61	89.59	145.77	235.36	-79.75
Boro season								
BAU farm								
0	0.00	3.48	5.51	8.99	5.69	115.26	120.95	111.96
30	30.00	3.48	5.51	38.99	15.43	135.28	150.70	111.71
60	60.00	3.48	5.51	68.99	22.57	150.93	173.50	-04.51
90	90.00	3.48	5.51	98.99	30.67	165.84	196.51	-97.52
120	120.00	3.48	5.51	128.99	45.35	162.12	207.46	-78.47
150	150.00	3.48	5.51	158.99	66.19	162.73	228.93	-69.94
BADC farm								
0	0.00	2.38	7.19	9.57	3.58	82.48	86.06	-76.49
30	30.00	2.38	7.19	39.57	14.59	110.02	124.60	-85.03
60	60.00	2.38	7.19	69.57	20.80	119.50	140.30	-70.73
90	90.00	2.38	7.19	99.57	32.58	133.86	166.44	-66.87
120	120.00	2.38	7.19	129.57	39.29	144.62	183.91	-54.34
150	150.00	2.38	7.19	159.57	46.89	144.65	191.54	-31.97

In BADC farm soil, the total input was 9.57 to 159.57 kg K ha^{-1} where 2.48 kg K ha^{-1} was added from rain water and 7.19 kg K ha^{-1} from irrigation water in addition to fertilizer. The leaching loss of K through percolation water was 3.58 to 46.89 kg ha^{-1} depending on K levels. The crop uptake of K was 82.48 to 144.65 kg ha^{-1} while total loss of K was 86.06 to 191.54 kg ha^{-1}. The input, leaching loss, uptake and total K loss increased as the levels of K increased. The rate of leaching loss of K was inconsistent for different levels of K. The leaching loss as well as crop uptake was relatively low in BADC farm soil. As a consequence, the negative balance of K was lower in BADC farm soil than BAU farm soil. The uptake K in general was higher than total input from different sources. In addition, more than 50% of added K was lost through leaching in all soils. As a result the balance was always negative. The results are in agreement with the findings of Ahsan *et al.* (1997); Rijpma and Jahiruddin (2004); Zhou *et al.* (2000) and Ladha *et al.* (2003).

Conclusion

The K fertility of our soil is decreasing very rapidly at alarming rate due to intensive cultivation of high yielding variety of rice with low K fertilizer dose. The BARC (2005) recommended up to 132 kg K ha^{-1} for high yield goal of rice. Our balance indicates that higher dose of K up to 150 kg K ha^{-1} improve K fertility of soil. However, considering the response of rice 60 – 90 kg K ha^{-1} may be recommended.

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RICE PRODUCTION SITUATIONS IN DIFFERENT AGRICULTURAL REGIONS OF BANGLADESH

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Abstract

The study was undertaken to determine total supply/production of demand for and supply-demand balance of rice in different production environments of Bangladesh; and determine the present storing capacity, quantity of paddy stored, storage time and benefits derived for storing paddy at farm level for providing policy options to the concerned agencies. A nation-wide survey of farm and non-farm households of different production environments was conducted in 15 villages under 15 randomly selected sample upazilas. From the analysis it was found that, the consumption of clean rice ranged from481-584 gm/capita/day among the seven rice production environments while farmers of saline area consumed less rice (481 gm/capita/day). All production environments were estimated to be more or less surplus in rice production. Some farmers sold paddy to meet-up their farm and household expenses even though they were deficit and/or marginally self-sufficient. The farmers who sold their excess production as deferred sale earned an additional benefit of Tk 34.00 to Tk 56.00 per 40 kg of paddy. Majority of sample farmers used to sell their paddy in the month Baisak (15 Apri,-14 May), Poush (15 December-14 January) and Jaista (15 May-14June) for Aus, Aman and Boro seasons, respectively. With this small amount of surplus production, the government still needs to think for increasing its buffer stock of at least 12.50 MMTs either through import or domestic procurement, so that the country's food security is ensured, if in case a crop season is affected due to the occurrence of any disaster. The total paddy storage capacity of sample farms was much less than their total production, which enabled them to sell their excess production immediately after harvest.

Introduction

Rice is the principal staple food of the people of Bangladesh. More than 90 percent of its' population consumes rice and derives 68 percent of the calories and 52 percent of the daily protein requirement (HIES, 2007). Rice provides more than 50 percent of the agricultural value added, covers 76 percent of the total cropped land, and accounts for 92 percent of total food grain production in the country. More than 55 percent of the rural labor force is employed by the rice sector (BBS, 2008). The most remarkable aspect of the agricultural performance in Bangladesh since its independence in 1971 is the accelerated rice production enabled the country achieving rice self-sufficiency in 1991 (World Bank, 1995). Available statistics reveals that rice production was 10.97 MMTs in 1970-71, which increased to 28.05 MMTs in 2006-07. The total share of rice to total food grain production is about 95 percent, and the share of MV rice constitutes 87 percent (HIES, 2007 and DAE, 2006). However, the country is still importing rice to the tune of 10-15 percent of her total food grain requirement every year. Natural calamities like floods, droughts and storms are common occurrences in the country, which cause to sudden damage to crop. To overcome such an unforeseen consequences, the

government has to think for importing certain quantity of food grain every year. The landless and poor people, who always depend on market, are in a vulnerable situation. So, the government has to maintain some stocks either by importing or by internal procurement to meet up emergency need every year, which in turn sell in the open market particularly for the distress and/or vulnerable people. On the other hand, 5-10 percent of the agricultural households are surplus producers, who are again stored a certain percent of their production for deferred sale for want of higher price. There is little information on distress sale at the farm level. Moreover, the estimation of demand for rice is calculated on the basis of 454 grams per capita per day, which needs to verify the changing income-consumption situation. The study highlighted the rice economy and generated a database on the rice scenario of different regions of Bangladesh, which would help planners, policy makers and importers to make proper planning on food grain import for meeting the speculated demand for food of the people of Bangladesh.

Materials and Methods

A nation-wide survey of different production environments of Bangladesh (i.e.,1= Non-flood/Non-drought (Dinajpur), 2 = Flood prone (Gaibandha), 3 = drought prone (Rajshahi), 4 = Saline (Satkhira), 5 = Tidal-submergence (Pirojpur), 6 = Hilly area (Bandarban) and 7 = Flash flood (Sunamgonj)) was conducted during April, 2008 – May, 2008. The report is based on primary level data collected from 240 sample farms of eight villages under eight upazilas Thirty farmers from each of the sample villages were selected at random on the basis of availability at home during the survey. The selected farmers were then interviewed using a set of structured questionnaire prepared and pre-tested in advance. The collected data were then coded, entered into the computer using Micro Soft Excel Program and validated using the computer program. The data were then analyzed using SPSS and presented in tabular form.

Results and Discussion

Production and requirement of paddy/clean rice

The sample farmers, on an average, consumed 537 gm/capita/day of clean rice, which is higher than that of average rice consumption i.e., 529 gm/capita/day as clean rice (FPMU, 2009). Total production/supply, requirement/demand and the estimate of supply-demand balance (i.e., surplus/deficit) of sample farms are also shown in Table 1. Seven production environments were surplus in paddy production (i.e., 307.02, 152.61, 236.11, 116.92, 116.59, 102.85 and 145.58 tons for non-flood/non-drought, flood-prone, drought-prone, saline, tidal-submergence, hilly and flash-flood production environments, respectively). On an average, the overall paddy production situation of the sample farmers in the seven production environments was surplus (1177.65 tons). This does not mean that these areas and/or all farms of the study areas were surplus in paddy production. However, the final conclusion will be made after completion of production and consumption survey of both farm and non-farm households in the year 2008-09.

Table 1. Production and requirement of paddy/clean rice by the sample farms, 2007-2008

Production Environments	Total paddy production by sample farms (tons)	Total paddy requirement by sample farms (tons)	Total paddy surplus/deficit at sample farm levels (tons)	Consumption of clean rice (gm/capita/ day)
1 = Non-flood/non-drought	361.08	54.06	+ 307.02	554
2 = Flood-prone	212.88	60.27	+ 152.61	564
3 = Drought-prone	276.76	40.65	+ 236.11	502
4 = Saline	154.92	38.00	+ 116.92	470
5 = Tidal submergence	156.95	40.36	+ 116.59	480
6 = Hilly area	160.36	57.52	+ 102.85	556
7=Flash flood	300.27	154.71	+ 145.58	586
All environments	1623.23	445.58	+ 1177.65	537

Source: Field Survey. NB: (+) indicates surplus

Paddy storage capacity at farm level

Table 2 showed the storage capacity of paddy at the sample farm level. All the sample farms were not able to store paddy at the similar rate. Some did not store, some stored less and some stored much depending upon their storage capacity. The average storage capacity of paddy of sample farms in the seven production environments was 1.99 t/hh. The farmers of flash-flood areas had less storage capacity (0.73 t/hh), while the farmers of drought-prone areas had highest storage capacity (3.75 t/hh) followed by flood-prone farmers (2.97 t/hh), non-flood and non-drought farmers (2.80 t/hh), tidal-submergence farmers (2.27 t/hh), hilly area farmers (1.40 t/hh) and saline area farmers (1.25 t/hh). The total storage capacity in the study areas was 477.76 tons, while their total production was 1623.23 tons resulted to a total of 1145.47 tons for marketing immediate after harvest. Thus, the farmers bound to sell the produces even though they wanted to store for sometimes for earning some benefits.

Table 2. Paddy storage capacity at sample farm household levels, 2007-2008

Production Environments	Total paddy Production (paddy) of sample farmers (tons)	Total storage capacity (paddy) of sample farmers (tons)	Average storage capacity (paddy) of sample farmers (tons)	Total paddy sold by sample farms immediate after harvest (tons)
1 = Non-flood/non-drought	361.08	81.28	2.80	279.80
2 = Flood-prone	212.88	89.20	2.97	123.68
3 = Drought-prone	276.75	116.20	3.75	160.55
4 = Saline	154.92	37.40	1.25	117.52
5 = Tidal submergence	156.96	68.00	2.27	88.96
6 = Hilly area	160.36	42.00	1.40	118.36
7 = Flash flood	300.28	43.68	0.73	256.60
All environments	1623.23	477.76	1.99	1145.47

Source: Field survey

Benefits derived from storing paddy

Farmers store paddy either for home consumption around the year or for deferred sale for want of higher price. Table 3 showed the benefit derived at the farm level for storing paddy in different seasons. Farmers earned, on an average, Tk 34.19 per md due to storing paddy sometimes in Aus season. The highest earning was Tk 60.10 per md in tidal-submergence environment followed by hilly area Tk 36.25 per md (1md = 40 kg as reported by farmers). The farmers of non-flood/non-drought, flood-prone and saline areas either did not store paddy or earn benefit from storing paddy in Aus season.

Table 3. Percent distribution of sample farms derived benefit from storing paddy, 2007-08

Production Environments	Benefit derived from storing Aus paddy (Tk/md)	Benefit Derived from storing Aman paddy (Tk/md)	Benefit Derived from storing Boro paddy (Tk/md)
1 = Non-flood/non-drought	-	75.42	68.50
2 = Flood-prone	-	41.58	33.68
3 = Drought-prone	21.58	29.37	30.42
4 = Saline	-	100.00	42.75
5 =Tidal submergence	60.10	81.79	-
6 =Hilly area	36.25	55.42	36.67
7 =Flash flood	22.00	53.33	49.00
All environments	34.19	55.57	40.54

Source: Field survey

Farmers' paddy selling behavior

Table 4 showed percent distribution of farms with their selling behavior of paddy in different seasons. Majority of sample farms (66.25%) did not sell Aus paddy. However, 22.50% farms sold Aus paddy after storing few months, while 11.25% sold just after harvest. In the case of Aman paddy, majority of sample farms (43.75%) sold paddy sometimes later than the harvesting time. Majority of the farmers (73.33%) in saline areas did not sell Aman paddy. Nearly 93 percent of Boro farmers never sold their paddy in Tidal-submergence whereas fifty and sixty percent never sold their paddy in Hilly and Flash flood. It was further observed that almost similar selling behavior reported by the Boro farmers in all other cases (Table 4).

Table 4. Percent distribution of sample farms with their selling behavior of paddy, 2007-08

Production environ-ments	Aus			Aman			Boro		
	% farms harvest sale	% farms differed sale	% farms never sale	% farms harvest sale	% farms differed sale	% farms never sale	% farms harvest sale	% farms differed sale	% farms never sale
1	-	-	100.00	24.14	62.07	13.79	34.48	58.62	6.90
2	-	-	100.00	36.67	63.33	-	30.00	63.33	6.67
3	25.81	61.29	12.90	16.13	77.42	6.45	16.13	77.42	6.45
4	-		100.00	-	26.67	73.33	-	76.67	23.33
5	6.67	33.33	60.00	30.00	50.00	20.00	6.67	-	93.33
6	23.33	66.67	10.00	26.67	40.00	33.33	20.00	30.00	50.00
7	16.67	8.33	75.00	28.33	15.00	56.67	23.33	16.67	60.00
All	11.25	22.50	66.25	23.75	43.75	32.50	19.17	42.50	38.33

Source: Field survey

Paddy selling months

Majority of the sample farms (84.91%) sold Aus paddy in the month of Baisakh. Only 3.77% and 11.33% sold in the months of Ashin and Kartic, respectively. The sample farms sold Aman paddy during the months of Agrahayan through Chaitra (Table 5). However, majority of them (45.36%) sold in the month of Poush followed by Agrahayan (26.80%), Chaitra (14.44%), Magh (12.37%) and Falgun (1.03%). The selling of Boro paddy started in the month of Magh and ended in Arshin. However, majority farms (65.12%) sold their boro paddy in the month of Jaista (Table 6).

Table 5. Percent distribution of sample farms sold Aman and Aus paddy after storing sometime, 2007-08

Production environments	Aus paddy (selling month)				Aman paddy (selling months)					
	Baisakh	Arshin	Kartic	Total	Agrayhon	Poush	Magh	Falgun	Chaitra	Total
1	-	-	-	-	25.00	58.33	16.67	-	-	100
2	-	-	-	-	52.63	42.11	-	-	5.26	100
3	72.22	5.56	22.22	100	-	58.33	-	-	41.67	100
4	-	-	-	-	66.67	33.33	-	-	-	100
5	100.00	-	-	100	-	17.65	58.82	5.88	17.65	100
6	85.00	5.00	10.00	100	27.27	72.73	-	-	-	100
7	100.00	-	-	100	75.00	25.00	-	-	-	100
All	84.91	3.77	11.32	100	26.80	45.36	12.37	1.03	14.44	100

Source: Field survey

Table 6. Percent distribution of sample farms sold Boro paddy after storing sometime, 2007-08

Production environments	Boro paddy (selling month)								
	Magh	Chaitra	Baisakh	Jaista	Ashar	Sraban	Bhadra	Arshin	Total
1	10.00	-	-	50.00	10.00	10.00	20.00	-	100
2	-	-	5.26	94.74	-	-	-	-	100
3	-	4.35	-	56.52	-	39.13	-	-	100
4	-	-	28.57	50.00	-	7.14	7.14	7.15	100
5	-	-	-	-	-	-	-		-
6	18.18	9.09	-	72.73	-	-	-	-	100
7	11.11	0.00	33.33	55.56	-	-	-	-	100
All	4.65	2.33	9.30	65.12	1.16	12.79	3.49	1.16	100

Source: Field survey

Conclusion and Recommendations

Paddy production was estimated as surplus in all of the rice production environments. This does not mean that all sample farmers were surplus in rice production. Some were deficit, some marginally self-sufficient and some were surplus in rice production. The consumption of clean rice was estimated to 537 gm/capita/day. Its consumption ranges from 470 - 586 gm/capita/day among the seven rice production environments. The sample farmers in the saline areas consumed less rice (470 gm/capita/day) compared to other rice production environments. The total storage paddy capacity of sample farms was much less than their total production, which compelled them to sell the access production just after harvest. The total paddy storage capacity of sample farms was much less than their total production, which enabled them to sell their access production immediately after harvest. So, Government should take good initiative to strengthen the storage capacity at the farm household level by providing financial and technical support. So, that farmers will be more benefited form deferred sale of their produces.

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PERFORMANCES OF THREE SHORT CYCLED FISH SPECIES IN THE SEASONAL PONDS IN NORTHERN BANGLADESH

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Abstract

Cultural trials of short cycled species GIFT (*Oreochromis niloticus*), silver barb (*Barbodes gonionotus*) and Thai koi (*Anabas testudineus*) were carried out during April to June for 120 days in seasonal ponds. GIFT, silver barb and Thai koi fingerlings of 0.93, 0.46 and 0.53 g body weights were stocked at the rate of 45,000/ha in four treatments viz., T_1 = GIFT:silver barb:Thai koi at ratio 1:1:1, T_2 = silver barb:Thai koi at ratio of 1:1, T_3 = GIFT:Thai koi at ratio 1:1 and T_4 = GIFT only. The fishes were fed with rice bran, fishmeal, mustard oil cake, wheat bran, wheat flour and vitamin premixes (28.66% protein) at 3-10% body weight twice daily. The mean water temperature was 29.13 ± 0.25°C, DO, 3.81 ± 0.79 mg/l, pH, 7.46 ± 0.12; hardness, 86.42 ± 14.97 mg/l and the transparency, 27.42 ± 2.01cm. The parameters among treatments varied insignificantly. The growth for GIFT, silver barb and Thai koi ranged from 142.0 to 222.5 g, 117.0 to134.0 g and 28.0 to 38.7 g, respectively. The growth of all three species showed better when cultured together in T_1. The growth of Thai koi was observed slower while cultured with silver barb. The species wise growth among treatments of Thai koi and silver barb were insignificant, while GIFT was found to be significant. The better performance was observed in three species (GIFT, silver barb and Thai koi) as the ratio 1:1:1, with production 4,260.58 Kg/ha in 120 days with FCR 1.41 and cost benefit ratio of 1:1.32.

Introduction

Inland aquaculture is the vital source of fish protein of Bangladesh where carp polyculture is the main practice throughout the country. About 1.3 million fishponds in the country, covering an area of 0.305 million ha and about 90.77% were in culture, while about 9.24% were cultivable or derelict (BBS, 2010). However, in the northern districts of Bangladesh about 55% ponds were observed to be seasonal of which 60% retained water for 4-6 months while 40% retained for 6 to 9 months (Haque *et al.* 2008). They reported that the majority of these ponds remained under unplanned fish culture or uncultivated and farmers were less interested due to lower production. Most of the fish farmers practiced very traditional ways and yet to develop the suitable technologies regarding species selectivity and culture management for utilization of such seasonal water bodies. There is great potential to increase fish production through utilizing these existing ponds through concurrent cultural attempts on short cycle species. Many fast growing short cycled fish species *viz.*, GIFT (*Oreochromis niloticus*), Thai koi/climbing perch of Thailand's strain (*Anabas testudinius*) and raj punti/silverbarb (*Barbodes gonionotus*) may have potential (Anon.1998; Haque *et al.* 2008, Adhikary *et al.*, 2009) for culturing scientifically. These short cycled species can be cultured in the seasonal ponds and their hatchery produced seeds are now available. Not much work regarding these species in seasonal ponds has been done in the Northern Bangladesh and data were few or fragmentary. In

this context, the present paper describes the culture trials of these three short cycled species in some selective seasonal ponds.

Materials and Methods

The experiment was carried out on cultural trials of BFRI GIFT, silver barb and Thai koi in seasonal ponds in Saidpur, Nilphamari during April to July 2009. There were eight ponds selected both from Bangladesh Fisheries Research Institute, Freshwater substation and from the volunteer farmers' each area range of 0.034-0.058 ha. The ponds were prepared by cleaning aquatic vegetation and lime (CaO) was applied at the rate of 125 kg/ha followed by cow dung 500 kg/ha as organic fertilizer and waited for two weeks. The ponds were filled with ground water through pump and applied urea 50 kg/ha and TSP 25 kg/ha and awaited for another week to allow the water to become suitable for stocking. The fish fry of BFRI GIFT was collected from the Freshwater Sub Station, Saidpur; silver barb, from DoF (Department of Fisheries) hatchery of Parbatipur and Thai Koi, from a private hatchery of Santahar, Bogra. GIFT, silver barb and Thai koi fingerlings of 0.93, 0.46 and 0.53g body weight species were stocked at the rate of 45,000/ha with combinations in four treatments, T_1 = GIFT: silver barb: Thai koi at ratio 1:1:1, T_2 = silver barb: Thai koi at the ratio of 1:1; T_3 = GIFT:Thai koi at the ratio of 1:1; and T_4 = GIFT only. The fish were fed (approximate 28.66% protein) with a mixture of rice bran (39.9%), fish meal (25%), mustard oil cake (20%), wheat bran (9%), wheat flour (6%) and vitamin premixes (0.1%) at 10% of their body weight twice daily at 10.00 hr and 16.00 hr that gradually decreased fortnightly. Water quality parameters such as temperature, pH, dissolved oxygen (DO), hardness, ammonia, depth and transparency were monitored and recorded weekly, while growth of the fishes were monitored every fortnightly by using cast net. Finally fishes were harvested by dewatering the ponds. Data were compiled and growth and production was estimated quantitatively and analyzed statistically. The net profit was estimated by calculating the gross return deducts from total variable cost (TVC). However, TVC was considered by including cost of land tenure/6 month, lime and fertilizers, fencing for Thai koi to prevent escaping, fish seed and feed ingredients. Besides cost benefit ratio (CBR) analysis was done as Morrice (1998).

Results and Discussion

Water quality parameters of different treatments *i.e.*, water temperature, pH, DO, hardness, ammonia, depth and transparency are shown in Table 1. No significant variation was observed in the treatments except transparency. The mean water temperature was remained 29.13 ± 0.25°C. Suitable range of water temperature was suggested by Mumtazuddin *et al.* (1982) and Rahman *et al.* (1982) to be 20.5-36.5°C. The mean value of pH was 7.46 ± 0.12 in the treatments that were suitable and agreed with Azim *et al.* (1995) and Kohinoor *et al.* (1998). DO was recorded to be 3.81 ± 0.79 mg/l during the period. The range was seemed to be lower, however, it agreed with Rahman *et al.* (1982) and Nirod (1997) who found the range within 2.2 to 8.79 mg/l. The mean content of ammonia was 0.69 ± 0.48 mg/l that seemed to be higher. Hardness was 86.42 ± 14.97 mg/l that seemed to be lower during the experimental ponds. However, Mollah and Haque (1978) mentioned the suitable range of ammonia to be 0.2-0.9 mg/l and hardness, 95-250 mg/l while Rahman (1992) indicated the range to be 0.4-1.5 ppm and 75-200 ppm of ammonia and hardness, respectively. The water transparency was observed to be 27.42 ± 2.01 cm that varied significantly ($P<0.05$) among treatments and were within optimal

range and that was agreed with Mumtazuddin *et al.* (1982) and Azim *et al.* (1995). Khan and Siddiquee (1974) also reported that the turbidity and phytoplankton affected the transparency of pond waters while Reid and Wood (1976) stated that the transparency of water was affected by the factors such a silting, microscopic organisms, suspended organic matter, latitude, season and intensity of incident light. However, in the present experiment, the major water quality parameters among treatments varied insignificantly and suitable for fish culture.

Table 1. Water quality parameters of different treatments during the period of experiment

Parameters	Treatment mean				Mean	Statistical Inference
	T_1	T_2	T_3	T_4		
Water temp. (^{0}C)	29.03±1.93	29.35±2.13	29.83±2.48	29.13±2.48	29.13±0.25	NS[1]
pH	7.56±0.30	7.31±0.27	7.55±0.32	7.40±0.49	7.46±0.12	NS
DO[2] (mg/l)	4.03±1.14	3.88±0.87	3.97±0.90	3.35±0.97	3.81±0.79	NS
Hardness (mg/l)	90.67±19.35	64.25±35.02	96.50±29.28	94.25±31.71	86.42±14.97	NS
Ammonia (mg/l)	0.29±0.13	0.43±0.33	0.73±0.62	1.31±0.82	0.69±0.48	NS
Water depth (cm)	80.70±13.97	86.50±17.92	97.85±22.07	80.70±13.97	83.83±20.27	NS
Transparency (cm)	25.05±5.03	28.45±4.48	31.80±4.61	24.38±3.87	27.42±2.01	S[3]

2= Dissolved Oxygen, 1=Not significant, 3=Significant ($p<0.05$)

Comparative growths of three species among treatments are shown in Fig. 1(a-c). Growth of all three species showed better when cultured together. Thai koi showed better growth when cultured with silver barb and GIFT, followed by combination with GIFT. The growth of Thai koi was observed to be slower while cultured with silver barb only (Fig. 1a).

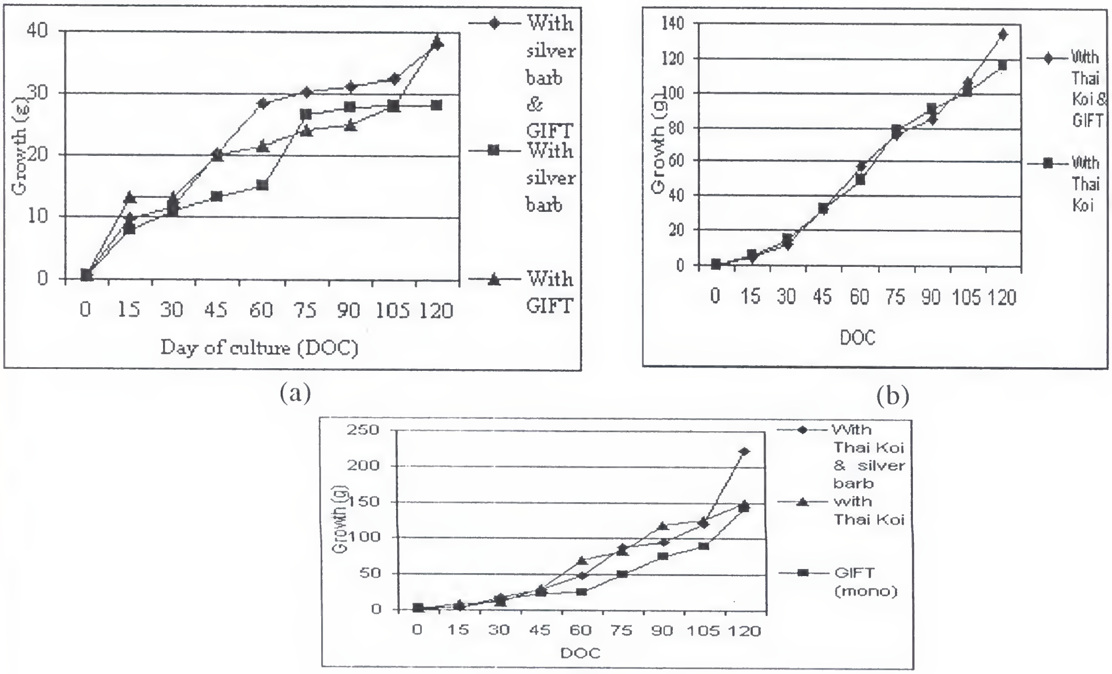

Fig. 1. Comparative growth of (a) Thai koi, (b) silver barb and (c) GIFT in treatments.

The species wise growth of Thai koi and silver barb among treatments was varied insignificantly; while the growth of GIFT was significant ($P<0.01$) among treatments (Table 2). The average final growth recorded for Thai koi was 38.00 ± 2.37, 28.00 ± 10.25 and 38.70 ± 9.25 g in the treatment T_1, T_2 and T_3, respectively and for silver barb, 134.00 ± 14.37 and 117.00 ± 15.83 g in the treatment T_1 and T_2, respectively. For GIFT the growth was 222.50 ± 39.78, 148.50 ± 36.66 and 142.00 ± 24.52 g in the treatment T_1, T_3 and T_4, respectively (Table 2). Siddik and Khan (2008) reported the average growth 112.40 ± 0.36 g for GIFT after 180 days of culture. The survival was determined from recovery of fishes at the end of the experiment and the survival rates were recorded for Thai koi to be 65.53 ± 10.01, 63.93 ± 12.05 and 66.73 ± 3.23% in T_1, T_2 and T_3, respectively which were lower than of other two species, GIFT and silver barb. Survival rates of GIFT was 75.87 ± 0.45, 78.44 ± 1.88 and 71.33 ± 1.97% in T_1, T_3 and T_4, respectively while for silver barb, they were 67.40 ± 0.53 and 76.19 ± 3.20% in T_1 and T_2, respectively (Table 2). The lower survival of Thai koi might be due to predation or severe escaping by nature. However, survival rates of the three species were similar as reported by Shah *et al.* (1998), Begum *et al.* (2003), Ahmed and Khair (2007) and Adhikary *et al.* (2009).

The specific growth rate (SGR%) was estimated for Thai koi to be 4.17, 3.86 and 4.18 in T_1, T_2 and T_3, respectively and for silver barb to be 5.56 and 5.42 in T_1 and T_2, respectively. For GIFT, they were 5.47, 5.07 and 5.02 in T_1, T_3 and T_4, respectively (Table 2). The obtained SGR (%) was similar to Shah *et al.* (1998), Begum, *et al.* (2003) and Adhikary *et al.* (2009). Comparatively slower growth rate was recorded in Thai koi in comparison to silver barb in T_2 which might be attributed to the higher stocking density as well inter and intra-specific dietary overlap between the two fishes. Mostakim *et al.* (2001) stated that the feeding patterns in respect of quality and quantity of food of silver barb varied with their size development. Haroon and Pittman (2000) reported that, interspecific dietary width was relatively broader for *B. gonionotus* than *Oreochromis* sp. as well as, intraspecific dietary overlap was also broad between sizes of tilapia.

In the present study, apparently higher production of 4,260.59 kg/ha/120days was recorded in T_1 (Table 2). This production was similar with Begum *et al.* (2003) and Ahmed and Khair (2007). Feed conversion ratio (FCR) was calculated as 1.41, 1.87, 1.85 and 1.61 for T_1, T_2, T_3 and T_4, respectively which were similar to Miah *et al.* (1993) and Mazid *et al.* (1997).

Table 2. Growth, survival and food conversion ratios of fishes in different treatments in ponds (120 days)

Treat-ment	Species	Pond's area (ha)	Stocking /ha	Initial weight (g)	Final weight (g)	Survival (%)	SGR (%)	Production (kg/ha)	Total prod. kg/ha	FCR
T_1	Thai Koi silver barb GIFT	0.058	15000 15000 15000	0.53±0.32 0.46±0.18 0.93±0.23	38.00±2.37 134.00±14.37 222.50±39.78^a	65.53±10.01 67.40±0.53 75.87±0.45	4.17 5.56 5.47	372.89 1355.58 2532.11	4260.59	1.41
T_2	Thai Koi silver barb	0.050	22500 22500	0.53±0.32 0.46±0.18	28.00±10.25 117.00±15.83	63.93±12.05 76.19±3.20	3.86 5.42	397.75 1997.14	2394.89	1.87
T_3	Thai Koi GIFT	0.039	22500 22500	0.53±0.32 0.92±1.57	38.70±9.25 148.50±36.66^b	66.73±3.23 78.44±1.88	4.18 5.07	583.22 2622.05	3205.27	1.85
T_4	GIFT (mono)	0.034	45000	0.92±1.57	142.00±24.52^b	71.33±1.97	5.02	4551.89	4551.89	1.61

The calculated net profit in 120 days was higher in T_1 (Tk. 96,239.85 /ha) followed by T_3 (Tk. 36,087.43 /ha) and T_4 (Tk. 35,239.51 / ha) while return obtained was negative in treatment T_2 (Tk. -21,012.52/ ha) were a combination of Thai koi and silver barb (Table 3). The calculated CBR was 1:1.32, 1:0.91, 1:1.13 and 1:1.12 in the treatment T_1, T_2, T_3 and T_4 respectively (Table 3).

Table 3. Total variable cost, gross margin, net profit and the cost ratio benefit in different treatments of seasonal ponds

Treatments	Variable Cost (Tk./ha)	Gross return (Tk./ha)	Net profit (Tk./ha)	Cost benefit ratio
T1	2,96,639.59	3,92,879.43	96,239.85	1:1.32
T2	2,30,460.27	2,09,447.75	-21,012.52	1:0.91
T3	2,92,044.84	3,28,132.26	36,087.43	1:1.13
T4	3,15,502.13	3,50,741.64	35,239.51	1:1.12

From the results of the experiment it could be said that the polyculture of Thai koi, silver barb and GIFT could be possible in seasonal ponds potentially in northern region. The better performance was observed in three species ratio of 1:1:1, with production of 4,260.58 Kg/ha in120 days with FCR 1.41 while the calculated cost benefit ratio was 1:1.32. However, environment of seasonal ponds could be suitable for other indigenous short cycled species like *Clarias sp., Heteropneustes sp.* but further research can be done.

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PERFORMANCE OF GERMINATION, GROWTH AND NODULATION OF LEGUMINOUS TREE SPECIES UNDER NURSERY CONDITION

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Abstract

Eight tree legumes species, namely- *Albizia procera* (Indian provenance), *Albizia chinensis* (Indian provenance), *Albizia procera* (local), *Albizia richardiana, Albizia chinensis, Leucaena leucocephala, Acacia auriculiformis* and *Acacia mangium* were tested at Bangladesh Forest Research Institute during 2006 to select suitable species for the reforestation programs in the degraded hilly areas. Germination percentage (99 %) was found higher in *Albizia procera* while *L. leucocephala* species showed higher germination value (22.45%) but *Leucaena leucocephala* showed higher sturdiness (16.90) and *Albizia richardiana* root-shoot ratio (2.72) in comparison to the remaining species. The shoot length, collar diameter and root length were higher in *L. leucocephala, A. procera (*Indian provenance) and *A. auriculiformis*. The former species showed higher nodule number but the total biomass, quality index and vigor index were significantly higher in *A. procera* (Indian provenance) and *L. leucocephala*. Considering the percentage of scoring of all these parameters, *L. leucocephala* ranked highest followed by *A. auriculiformis*, and has been considered suitable species for plantation programs in degraded soils in hilly areas.

Introduction

The degraded hill forest areas of Bangladesh suffer from low fertility and creating problems for the successful establishment of plantations of some common timber species (Hossain *et al.* 2001). Nitrogen fixing tree species (NFTs) may be considered suitable for successful plantation programs in such degraded forest areas as they may enrich the depleted soil by atmospheric nitrogen fixation through their root nodules (Chaukiyal *et al.* 1999 and 2000). Leguminous trees also help in speedy recovery of degraded lands due to fast decomposition of litter fall (Anegbeh *et al.* 1999, Prinsen 1986 and Semwal *et al.* 2003). Considering the importance of nitrogen fixing tree species to increase soil fertility and improving the forest productivity of plantation programs, legumes are priority tree species in plantations programs. Legumes are also multipurpose, colonizing, fast growing forest tree species and are common tree components in agroforestry and other participatory forestry practices in the country. But, information on seed germination, seedling growth and nodulation potential of tree legumes species are scant in Bangladesh. In this context, an experiment was established with some leguminous tree species, viz., *A. procera,* (Indian provenance), *A. chinensis*– (Indian provenance), *A. procera* (local), *A. richardiana*, *A. chinensis*, *L. leucocephala, A. auriculiformis,* and *A. mangium* in the nursery of Bangladesh Forest Research Institute (BFRI) with the objective of the study was to assess the germination, growth and root nodulation behavior of the species in the nursery.

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Materials and Methods

The study was conducted in the nursery of Silviculture Research Division (SRD) of BFRI, Chittagong in 2006. Seeds were collected from Seed Orchard Division (SOD) of BFRI. In addition to the local seed sources, seeds of *A. procera* and *A. chinensis* were collected from Uttar Pradesh, India and treated as Indian provenances. Seeds were sown in 23 cm x15 cm size polybag filled in with forest top soil and decomposed cow-dung in a proportion of 3:1. Seeds of all the species were treated with hot water for 30 seconds before sowing. A total of 800 polyethylene bags were filled and seeds were sown for all six species (8 species/provenances) x 4 replications x 800 polyethylene bags). Three seeds of each species were sown in a polybag at equal depth and 15 cm apart from each other. Watering was carried out regularly by fine shower which could not disturb the seedlings physically. Weedings and cleaning were done as and when necessary. Seed germination records maintained daily till 70 days of the experiment. After 50 days of seed sown, one healthy seedling was kept in each polybag and others were removed carefully. Seedlings height, root height, shoot height, collar diameter and dry root biomass of shoot and nodules were recorded. After 150 days of seed sown, five seedlings were randomly collected from the nursery. Then the seedlings were carefully washed with tap water and roots of the seedlings were floated in water. The washed roots were wrapped with soft tissue paper and nodules were detached from individual seedlings and further washed carefully to remove all particles. Fresh weights as well as dry weight of different components of the seedlings were recorded. The germination values (GV) were calculated by using the formula of Djavanshir and Pourbeik (1976):

$$GV = (\sum DGs / N) \times GP / 10$$

Where,	GV	=	Germination value
	GP	=	Germination percentage at the end of the test
	DGs	=	Daily germination speed obtained by dividing the cumulative germination percentage by the number of days since sowing
	Σ DGs	=	The total germination obtained by adding every DGs value obtained from the daily count
	N	=	The total number of daily counts, starting from the date of first germination
	10	=	Constant

To assess the seedling vigor index, total height (from the soil surface to seedling tip) of each seedling was measured using a ruler to nearest 0.1 cm. Vigor index was calculated according to Baki and Anderson (1973) as germination percent × seedling total length, i.e., total shoot and root length.

Quality Index (QI) to qualify seedling morphological quality was calculated following the method of Dickson and Hosner (1960):

Quality Index (QI) = Total weight (g) ÷ [{Height (cm) ÷Collar diameter. (cm)} + {Shoot dry weight (g) ÷ (Root dry weight (g)}]

The Sturdiness and Root-shoot ratio were calculated:

Sturdiness = Height ÷ Collar diameter

Root-shoot ratio = Total green weight of root ÷ Total green weight of shoot

Duncan Multiple Range Test (DMRT) was applied to compare the differences of all the species.

Results and Discussion

Germination percentage was maximum (99%) in *A. procera* (local) followed by *A. chinensis* (88%), *L. leucocephala* (79%), *A. auriculiformis* (76%) and *A. mangium* (73%). However, poor germination was found in *A. procera (*Indian Provenance) (32%), *A. richardiana* (32%) and *A. chinensis (*Indian provenance) as 39%. Highest sturdiness attained in *A. auriculiformis* (16.90) followed by *L. leucocephala* (14.82) and *A. procera* (13.02) and lowest sturdiness attained in *A. procera (*Indian provenance) as 9.82. The root-shoot ratio of all the species was less than 1 except in *A. richardiana* (2.72) and *L. leucocephala* (1.76). However, germination value was highest (22.45) in *L. leucocephala* followed by *A. mangium* (18.65) and *A. chinensis* (18.08) whereas lower germination value attained in *A. richardiana* (1.40) but at par to *A. procera* Indian provenance (2.10) and *A. chinensis* - Indian provenance (4.35) (Table 1).

Table 1. Germination (%), sturdiness, root-shoot ratio and germination value (GV) of six tree legume seedlings in nursery

Species	Germination (%)	Sturdiness	Root-Shoot ratio	Germination value
Albizia procera- Indian provenance	32 b*	9.82 c	0.84 b	2.10 d
Albizia chinensis- Indian provenance	39 b	11.85 bc	0.99 b	4.35 d
Albizia procera	99 a	13.02 abc	0.72 b	16.67 b
Albizia richardiana	32 b	10.47 bc	2.72 a	1.40 d
Albizia chinensis	88 a	12.22 bc	0.65 b	18.08 ab
Leucaena leucocephala	79 a	14.82 ab	1.76 a	22.45 a
Acacia auriculiformis	76 a	16.90 a	0.88 b	11.18 c
Acacia mangium	73 a	10.17 bc	0.80 b	18.65 ab

*The same letter(s) in the same column are not significantly different by Duncan's Multiple Range Test (DMRT) at 5% level of probability.

Seedling growth performances, e.g., seedlings height, root length, collar diameter, green weight of the seedlings (leaf, shoot and root), nodules number and dry weight were assessed with some legume forest tree species in the nursery. The mean height of the seedlings was highest (111.5 cm) in *L. leucocephala* which significantly different from the rest species (Table 2). Lower height was found in *A. mangium* (29.8cm) followed by *A. richardiana* (35.27 cm) and *A. auriculiformis* (46.49 cm).

Considering collar diameter of the seedlings, *A. procera*- Indian provenance attained highest collar diameter (8.28 mm) which significantly different from others. The mean lower collar diameter attained in *A. auriculiformis* (2.97 mm) which was at par to *A. mangium* (3.20 mm), *A. richardiana* (3.25 mm) and *A chinensis*- Indian provenance (4.89 mm). The species *A. auriculiformis* possessed higher root length (38.8 cm) followed by *A. procera (*Indian provenance) (35.95 cm) and *L. leucocephala* (34.87 cm). Mean total green weight was maximum (86.05 g) in *A. procera*- Indian provenance closely followed by *L. leucocephala* (85.50 g) whereas lower in *A. mangium* (11.70 g).The number of nodules was maximum in *L. leucocephala* (43) followed by *A. chinensis* (36) and lowest nodules number attained in *A richardiana* (2). However, the nodule dry weight was maximum (0.25 g) in *A. chinensis* - Indian provenance followed by *A. procera* (0.20 g), *A. procera*- Indian provenance (0.20g) and *A. auriculiformis* (0.15 g) (Table 2). The air dry weight of seedlings (leaf, shoot and root) of different species was statistically significant (Table 3). Mean leaf and twig was higher (10.39 g) in *A. chinensis* - Indian provenance followed by *A. procera* Indian provenance (9.34 g), *L. leucocephala* (8.0 g), *A. chinensis* (7.05 g) and *A. auriculiformis* (3.55 g). Considering the mean shoot dry weight of the

Table 2. Comparative shoot length, collar diameter, root length, total green weight, nodule number and weight of the seedlings

Species	Shoot length (cm)	Collar diameter (mm)	Root length (cm)	Green weight (g)			Total green weight (g)	Nodules number	Nodule dry weight (g)
				Leaf and twig	Shoot	Root			
Albizia procera- Indian provenance	82.19 b	8.28 a	35.95 ab	40.50 a	25.65 ab	19.90 ab	86.05 a	18 bc	0.20 ab
Albizia chinensis - Indian provenance	58.66 bc	4.89 cd	26.05 bc	28.55 abc	17.40 bcd	16.70 b	62.65 ab	18 bc	0.25 a
Albizia procera	74.7 b	6.04 bc	27.6 bc	14.4 abc	11.93 cde	8.80 b	35.13 bc	16 bc	0.20 ab
Albizia richardiana	35.27 cd	3.25 d	18.3 c	2.9 c	2.55 e	6.65 b	12.10 c	2 d	0.01 d
Albizia chinensis	71.68 b	5.91 bc	23.55 c	32.50 ab	20.25 abc	13.10 b	65.85 ab	36 a	0.12 bcd
Leucaena leucocephala	111.53 a	7.53 bc	34.87 ab	19.90 abc	31.40 a	34.20 a	85.50 a	43 a	0.09 cd
Acacia auriculiformis	46.49 cd	2.97 d	38.8 a	14.30 abc	8.30 de	6.90 b	29.50 bc	21 b	0.15 abc
Acacia mangium	29.80 d	3.20 d	28.15 bc	4.95 bc	3.75 e	3.00 b	11.70 c	7 cd	0.05 cd

- Letter(s) in the same column are not significantly different by Duncan's Multiple Range Test (DMRT) at 5% level of proability.

L. leucocephala produced the maximum shoot dry weight (11.73 g) followed by *A. chinensis* -Indian provenance (10.35 g) and *A. procera* Indian provenance (8.03 g) and lowest by *A. mangium* (0.75 g). Similarly, root dry weight was maximum (8.13 g) in *A. chinensis* - Indian provenance followed by *A. procera* Indian provenance (6.29 g), *L. leucocephala* (5.8 g), *Aprocera* (4.69 g), and *A chinensis* (4.53 g) and lowest by *A. mangium* (0.27 g) . The total dry weight was maximum (28.86 g) in *A. chinensis* - Indian provenance followed by *L. leucocephala* (25.53 g), *A. procera (*Indian) (23.66 g) and *A. chinensis* (20.18 g) and lower dry weight attained by *A. mangium* (1.88 g) followed by *A. richardiana* (6.0 g), *A. auriculiformis* (8.84 g) and *A. procera* (10.39 g).

Vigor index varied significantly among the seedlings though there was variation among the species. *L. leucocephala* possessed higher vigor index (11516.1) followed by *A. procera* (10130.1) while lower value (1378.9) in *A. richardiana.* Both indian species, *A. chinensis* and *L. leucocephala* showed similar quality index which was significantly at par. The lower quality index was obtained from *A. mangium* followed by *A. auriculiformis* (Table 3).

It is difficult to ranking the growth of plants in sequential order considering all the parameter together. Therefore, a numerical ranking system was followed taking into consideration the total number of studied plants and parameters. All the species were graded one to six considering their responses from higher to lower order for the individual parameter and finally scores obtained by each plant for all parameters were added and percentage value were calculated (Thatoi *et al.* 1995).

Table 3. Total dry weight, vigor index and quality index of the seedlings grown in polybags

Species	Air Dry weight (g)			Total dry weight (g)	Vigor index	Quality index
	Leaf and twig	Shoot	Root			
Albizia procera- Indian provenance	9.34 ab	8.03 abc	6.29 ab	23.66 a	3954.8 de	2.17 a
Albizia chinensis- Indian provenance	10.39 a	10.35 a	8.13 a	28.86 a	3095.8 ef	2.19 a
Albizia procera	1.96 bc	3.74 bcd	4.69 abc	10.39 bc	10130.1 ab	0.67 bcd
Albizia richardiana	2.00 bc	2.00 d	2.00 cd	6.00 c	1378.9 f	0.56 bcd
Albizia chinensis	7.05 abc	8.60 ab	4.53 abc	20.18 ab	8393.0 bc	1.42 abc
Leucaena leucocephala	8.00 abc	11.73 a	5.80 abc	25.53 a	11516.1 a	1.5 ab
Acacia auriculiformis	3.55 abc	2.96 cd	2.33 bcd	8.84 bc	6294.4 cd	0.48 cd
Acacia mangium	0.86 c	0.75 d	0.27 d	1.88 c	4190.3 de	0.15 d

Letter(s) in the same column are not significantly different by DMRT at 5% level of probability

Conclusion

Considering the percentage scoring, it was found that *L. leucocephala* occupied the highest rank followed by *A. procera*, *A. chinensis*, *A. auriculiformis*, *A. mangium*, *A. procera* -Indian provenance, *A. chinensis* - Indian provenance and *A. richardiana*. The poorest of performance was found in *A. richardiana*. Considering scoring data, *L. leucocephala* is considered as a suitable species for the plantation programs followed by others. Since the highest root length attained in *A. auriculiformis* and *L. leucocephala*, these species are suitable for plantation programmes followed by others in degraded soils in hilly areas of Chittagong and Chittagong Hill Tracts. However, further research should be carried out with more leguminous multipurpose forest tree species at field level before taking for large scale plantation programs in degraded hilly areas.

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EFFECT OF INTEGRATED ORGANIC AND INORGANIC FERTILIZER ON NUTRIENT UPTAKE BY RICE

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Abstract

A field experiment was conducted to assess the effects of integrated use of urea with cowdung, poultry manure and urban wastes in boro rice (Var.BRRIdhan29) at the Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur during 2008-2009. Urea at the rate of 47.5 kg N/ha (50% of recommended N) along with PKS and cowdung, poultry manure or urban wastes at the rates of 11.5, 9.5 or 11.8 t/ha, respectively resulted in better nutrient uptake by grain or straw compare to urea alone, but the effect of poultry manure was the most pronounced than that of cowdung and urban wastes. Soil pH value decreased slightly as compared to that of initial soil. Application of urea-nitrogen alone slightly decreased the organic matter, total N and available P contents. The overall results indicate that urea nitrogen at the rate of 47.5 kg/ha along with PKS and 9.5 t poultry manure/ha was the best treatment for higher sustainability of soil fertility.

Introduction

Bangladesh soils have been depleted with several essential nutrients mainly because of intensive cultivation having no return from organic recycling. Fertilizers are indispensable for the crop production systems of modern agriculture and inorganic fertilizers today hold the key to success of the crop production systems of Bangladesh agriculture, being responsible for about 50% of the total production (FRG, 2005). But, it is also true that maintaining the sustainable crop production is difficult by using chemical fertilizers alone or using organic manure only (Bair, 1990).

The combined use of organic manures and inorganic fertilizer might be helpful for sustainable crop production and maintenance of soil fertility. Nambiar (1991) also reported that integrated use of organic manure and chemical fertilizers would be quite promising not only in providing greater stability in production, but also in maintaining higher soil fertility status.

Cowdung, a common manure in Bangladesh, can play a vital role in soil fertility improvement as well as in supplying most of the macro and micronutrients. BRRI researchers reported that inclusion of cowdung at the rate of 5 t/ha/year improved the rice productivity as well as prevented the soil resources from the degradation (Bhuiyan, 1991).

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In the recent years, poultry farms of the different sizes have been established all over the country. Poultry farm holders use concentrated feeds to feed their poultry birds. As a result the poultry excreta are rich in nutrients. As the poultry excreta are not used as fuel, these can be the good source of nutrients for field crops. Urban wastes products generally available and is not used widely due to lack of knowledge but it can be used for crop production.

Despite the fact that the soil fertility research in Bangladesh has been carried out for long time but the cropping pattern based fertilizer research is relatively scarce to evaluate the effect of integrated use of urea with cowdung, poultry- manure, urban wastes on the yield and nutrient uptake by crops and soil properties in the rice-rice pattern.

Materials and Methods

The experiment was carried out at the Research Farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur during boro season of 2008-09. The soil belongs to Madhupur Tract (AEZ 28), Salna series and is fall the order of Inceptisols. A high yielding variety BRRIdhan29 was used as the test crop. The soil was silty clay loam mentioning porosity 48.50%, bulk density 1.29 g/cc, particle density 2.58 g/cc, pH 5.80, organic carbon 0.83%, total N 0.12%, available P 12.90 ppm, exchangeable K 0.52 meq./100 g soil and available S 12.98 ppm. Cowdung contained 0.82% N, 0.25% P, 0.50% K and 0.11% S, poultry manure 1.00% N, 0.30% P, 0.55% K and 0.16% S and urban wastes 0.80% N, 0.21% P, 0.45% K and 0.09% S. The randomized Complete Block design (RCBD) with three replications was used for the experiment. The unit plot size was 4.0 m × 2.5 m. Treatments were: T_0 = control, T_1 = 47.5: N:28P:57K:15 S Kg/ha, T_2 = 75: N:28P:57K:15 S Kg/ha, T_3 = 95:N:28P:57K:15S Kg/ha, T_4 = 47.5:N:13.63 P:28.3K:8.68 S Kg/ha + CD 5.75 t/ha, T_5 = 71.5:N:13.63 P:28.3K:8.68 S Kg/ha + CD 2.85 t/ha, T_6 = 47.5:N: 4.75 P Kg/ha + PM 4.75 t/ha, T_7 = 71.5:N:13.75 P:30.88 K:7.4 S Kg/ha + PM 2.37 t/ha, T_8 = 71.5:N:13.75 P:30.88 K:7.4: S Kg/ha + UW 5.75 t/ha, and T_9 = 71.5:N:9.75 P:30.50K:9.69 S Kg/ha + PM 2.85 t/ha,. Each treatment received equally 1.0 Zn Kg/ha and phosphorus, potassium and sulphur were adjusted where organic manures were applied. Recommended dose and fertilizer application method was used (FRG, 2005). Ninety five Kg N was used on 100% basis in treatment T_3 and subsequently 50% and 75% @ 47.5 and 71.7 Kg N/ha for treatment T_1 and T_2, respectively. Well decomposed poultry manure (PM), cowdung (CD) and Urban wastes (UW) were applied 25 and 50% basis of the recommended dose as per treatments one week before final land preparation. Nitrogen as urea was top dressed in three equal installments (splits) at 12, 35 and 58 days after transplanting. Thirty five days old seedlings were transplanted on 10 January, 2008. Distances of 20 cm from row to row and 15 cm from plant to plant were maintained. Intercultural operations like weeding and irrigations were done as and when necessary. The crops were harvested plot wise at maturity after 155 days in boro season (seed to seed). The analysis of variance for the crop characters and also the nutrient content of the plant samples were done following the ANOVA technique and the mean values were adjusted by Duncan's Multiple Range Test (DMRT).

Results and Discussion

Nitrogen uptake by grain

The effect of different treatments on nitrogen uptake by grain is shown in Table 1. There was a significant variation among the treatments in respect of nitrogen uptake by grains.

The maximum nitrogen uptake by grains (63.16 kg/ha) of rice was observed in T_6 treatment receiving 47.50 kg N in combination with 9.50 t poultry manure/ha which was statistically superior to the rest of the treatments. The uptake of nitrogen by grain ranged from 27.52 to 63.16 kg/ha. However, nitrogen fertilizer in association with poultry manure, cowdung and urban wastes responded better than treatment receiving only nitrogen. Treatment T_6 recorded 129.50% higher nitrogen uptake than control treatment. The lowest nitrogen uptake (27.52 kg/ha) by grain was noted in control (T_0). These results are in agreement with the findings of Sharma and Mitra (1991). Azim (1999) and Hoque (1999) carried out experiments with organic manures and fertilizers together and found significantly higher N uptake in grain over control.

Phosphorus uptake

Phosphorus uptake by grain was significantly influenced by the application of chemical nitrogen fertilizer and organic manure viz. poultry manure, cowdung and urban wastes (Table 1). Phosphorus uptake by grain varied from 27.46 to 10.07 kg/ha and the maximum phosphorus uptake (27.46 kg/ha) was noted in the treatment T_6 (N_{50}+PM_{50}) which was significantly different to the rest of the treatments. However, all the treatments receiving chemical nitrogen fertilizer along with organic manures responded better than control treatment. The lowest phosphorus uptake (10.07 kg/ha) by grain was found in control treatment (T_0). Treatment T_6 produced 172.69% higher phosphorus uptake than control treatment. Gupta *et al.* (1995) reported the highest phosphorus uptake by rice with combined application of poultry manure (PM) and fertilizer phosphorus. Similar results were also reported by Hoque (1999) and Azim (1999).

Potassium uptake

A significant variation in potassium uptake by grain was observed due to the application of different levels of organic fertilizer along with organic manures (Table 1). The maximum potassium uptake by grain (13.17 kg/ha) was found by T_6 treatment receiving 47.50 kg N along with 9.50 t poultry manure/ha. The lowest potassium uptake by grain (4.73 kg/ha) was found in control (T_0) treatment. Treatment T_6 noted 178.43% higher potassium uptake than control treatment. The results of this experiment showed that potassium uptake by rice grain was increased due to the application of chemical nitrogen fertilizers along with manures. Cassman (1995) found that potassium uptake increased with the increasing organic matter. These results are in good agreement with Jagadeeswari *et al.* (2001) who reported increased potassium uptake in rice grain due to the application of cowdung along with NPK fertilizers.

Sulphur uptake

Sulphur uptake by grain was significantly influenced by different treatments of urea nitrogen and organic manures (Table 1). Sulphur uptake by rice grain was varied from 7.18 to 2.74 kg/ha. The highest sulphur uptake by grain (7.18 kg/ha) was observed by treatment T_6 (N_{50} + PM_{50}) which was statistically higher them to the rest of the treatments and the lowest sulphur uptake by grain (2.74 kg/ha) was found in control treatment. Treatment T_6 noted 162.04% higher sulphur uptake than control treatment. Poongothai *et al.* (1999) observed that application of suphur significantly enhanced sulphur uptake by rice. Islam *et al.* (1986) and Poongothai *et al.* (1999) reported that application of sulphur significantly increased sulphur uptake by rice.

Table1. Effects of urea nitrogen, cowdung, poultry manure and urban wastes on nitrogen, phosphorus, potassium and sulphur uptake by rice grain

Treatment	N uptake (kg/ha)	P uptake (kg/ha)	K uptake (kg/ha)	S uptake (kg/ha)
T_0	27.52h	10.07f	4.73g	2.74i
T_1	45.11g	17.60e	9.62f	5.06h
T_2	47.25f	18.22e	10.06e	5.24g
T_3	49.06e	18.66e	10.30e	6.93b
T_4	57.82b	24.06b	12.44b	6.82b
T_5	51.03d	21.49cd	10.82d	5.90d
T_6	63.16a	27.46a	13.17a	7.18a
T_7	52.15c	22.37c	11.08c	6.18c
T_8	52.49c	22.12c	11.26c	6.17c
T_9	49.78e	20.62d	11.19c	5.82d
CV (%)	9.37	8.32	6.18	7.38

Means in a column followed by same letter (s) are not significantly different at 5% level of significance by DMRT

Nitrogen uptake by straw

Chemical fertilizer along with poultry manure, cowdung and urban wastes significantly increased N uptake by straw compared to only nitrogen and control treatments (Table 2). The maximum N uptake of 43.01 kg/ha was noted in treatment T_6 receiving 47.50 kg N with the association of 9.50 t/ha poultry manure. Treatment T_6 receiving chemical nitrogen fertilizer along with 9.50 t poultry manure/ha produced 194.58% higher nitrogen uptake over control. The lowest value of N uptake by straw (14.60 kg/ha) was recorded in control (T_0) treatment.

Phosphorus uptake

Effect of nitrogen fertilizer and organic manures on phosphorus uptake by straw was significant (Table 2). Treatment T_6 receiving 47.50 kg N along with 9.50 t poultry manure/ha recorded the maximum P uptake (7.44 kg/ha) which was statistically superior to the rest of the treatments. The minimum P uptake by straw (3.37 kg/ha) was found in control. Treatment T_6 produced 120.77% higher phosphorus uptake by straw over control. This might be due to the application of chemical nitrogen fertilizer in association with organic manures which might have increased efficiency of phosphorus accumulation in straw result higher phosphorus uptake in straw. Chemical fertilizer along with poultry manure at the rate of 3 t/ha increased phosphorus uptake in rice (Anonymous, 2007a).

Potassium uptake

Potassium uptake by straw was significantly varied with different levels of chemical nitrogen fertilizer along with poultry manure, cowdung and urban wastes (Table 2). The maximum K uptake (68.44 kg/ha) by straw was found in T_6 treatment receiving 47.50 kg N along with 9.50 t/ha poultry manure. Chemical nitrogen with the combination of cowdung, poultry manure and urban wastage increased potassium uptake. Control treatment produced the minimum potassium uptake (37.05 kg/ha). Treatment T_6 produced 84.72% higher potassium uptake over control. Jagadeeswari *et al.* (2001) also observed that the potassium uptake by rice was increased by the application of organic manure with nitrogen, phosphorus and potassium. Chemical fertilizer with the association of poultry manure at the rate of 2 t/ha increased phosphorus uptake in rice (Anonymous, 2007b).

Sulphur uptake

The crop showed a good response to nitrogen fertilizer along with organic manure in recording S uptake by straw (Table 2). The highest sulphur uptake (7.07 kg/ha) was obtained by the treatment T_6 (N_{50} + PM_{50}) which was statistically significant to the rest of the treatments. Chemical nitrogen fertilizer in association with poultry manure (T_6) produced 139.66% higher nitrogen uptake over control. This might be due to the application of poultry manure, cowdung and urban wastes along with nitrogen fertilizer results comparatively better condition exploited more sulphur uptake by straw of BRRIdhan rice. The lowest sulphur uptake by straw (2.95 kg/ha) was found by control treatment.

Table 2. Effects of urea nitrogen, cowdung, poultry manure and urban wastes on nitrogen, phosphorus, potassium and sulphur uptake by rice straw

Treatment	N uptake (kg/ha)	P uptake (kg/ha)	K uptake (kg/ha)	S uptake (kg/ha)
T_0	14.60g	3.37i	37.05f	2.95h
T_1	28.92f	5.38h	52.39e	5.14g
T_2	30.16e	5.64g	54.33d	5.33f
T_3	30.42e	5.74fg	54.76d	5.41ef
T_4	36.56b	7.13b	64.68ab	6.58b
T_5	30.67e	5.94ef	55.20d	5.64de
T_6	43.01a	7.44a	68.44a	7.07a
T_7	31.45d	6.14cd	56.22b	5.73cd
T_8	32.34c	6.30cd	57.36b	5.89cd
T_9	30.72e	6.03de	55.09d	5.60ef
CV (%)	6.75	8.23	9.21	4.65

Means in a column followed by same letter (s) are not significantly different at 5% level of significance by DMRT

Effect on soil properties

Soil pH

The effects of urea nitrogen, poultry manure, cowdung and urban wastes on the pH values of the post-harvest soils have been presented in Table 3. The pH value of the post-harvest soils ranged from 5.9 to 6.1 as compared to initial pH value 5.8. All the treatments caused a decreasing effect on the pH value of the post harvest soils compared to the control but the values were inconsistent when compared with that of the initial soil. The decreasing effect was more where manures were applied. The lowest value of pH (5.90) was observed in T_6 and the highest value (6.10) was recorded in T_0 (control). The pH value of the post harvest soils decreased might be due to the organic acids released from the decomposition of organic manures. Swarup and Singh (1994) reported that the application of FYM decreased the soil pH compared with the control. Similar results were also observed by Kumar and Mishra (1991); Islam (1997) and Khan (1998).

Organic matter

The organic matter content of the post harvest soils was decreased due to application of fertilizers while results were reverse when manure were applied (Table 3). The organic matter content of the post harvest soils varied from 1.14 to 1.90 %. It was observed that organic matter content tended to increase in the soils treated with organic manures. The highest value of organic matter content (1.90%) was observed in the treatment T_6 and the lowest value (1.04%) in T_1 (N_{50}) treatment. Mathew and Nair (1997) reported that cattle manure alone or in combination with chemical fertilizer of NPK increased the organic carbon content.

Total Nitrogen

Total nitrogen content of post harvest soils varied is presented in Table 3. Soils treated with organic manure showed a slight increase in total N content of post harvest soils. Chemical fertilizers have a tendency to decrease the total N content in post harvest soils. The total nitrogen content of the post harvest soils ranged from 0.083 to 0.105 % as compared to the value of 0.063 of the initial soil and the highest value was observed in T_6. The results indicated that application of organic manures exerted an increasing effect on the total nitrogen content as well as the organic matter content of the post harvest soils. Rice cultivation with chemical fertilizers tended a decreasing effect on the organic matter and total N content of the soil. Mathew and Nair (1997) reported that organic manures increased the organic carbon, total N and available P content in soils.

Available Phosphorus

Post harvest soils were influenced slightly and inconsistently due to different treatments (Table 3). Available P of the post harvest soils ranged from 12.41 to 13.90 ppm against the P content of 12.9 ppm in initial soil. Available P of the post harvest soils increased slightly in all cases as compared to the initial soils except for the control. The highest and the lowest available P content were recorded in T_6 treatment. Soil treated with organic manures gave higher values of available P compared to other treatments. The release of available P from the decomposition of cowdung, poultry manure and urban wastes might be the cause of higher available P in soils treated with organic manures. Organic carbon, total N and available P content in soils increased due to application organic manures was reported by several workers (Sharma and Sharma, 1994 and Mathew and Nair, 1997).

Exchangeable Potassium

Due to application of chemical fertilizers and organic manures, exchangeable potassium content of the post harvest soils was also influenced. Potassium content in post-harvest soils ranged from 0.53 to 0.56 meq./100g soil (Table 3). Potassium content varied inconsistently and the application of cowdung, poultry manure and urban wastes caused a slight increase and K content over the initial value. It is also indicated that exchangeable K content was higher in soils treated with organic manures than those treated with chemical fertilizers. More (1994) observed that FYM and pressmud increased availability of N, P and K in soil.

Table 3. Effect of urea nitrogen, cowdung, poultry manure and urban wastes on the properties of the post harvest soils

Treatment	pH	Organic matter (%)	Total Nitrogen (%)	Available phosphorus (ppm)	Exchangeable potassium (meq/100g soil)	Available sulphur (ppm)
T_0	6.10	1.04	0.083	12.41	0.53	12.01
T_1	6.08	1.12	0.089	12.84	0.54	13.00
T_2	6.08	1.11	0.090	12.85	0.54	13.01
T_3	6.09	1.10	0.091	12.90	0.54	13.01
T_4	5.91	1.88	0.101	13.60	0.55	14.10
T_5	5.92	1.84	0.099	13.29	0.55	13.80
T_6	5.90	1.90	0.105	13.90	0.56	14.30
T_7	5.92	1.88	0.101	13.56	0.55	13.95
T_8	5.93	1.89	0.103	13.63	0.55	14.05
T_9	5.94	1.88	0.101	13.48	0.55	13.80

Available Sulphur

A little variation in available S content of post harvest soils due to different treatments (Table 3). Available S content of all the post harvest soils were found considerable higher as compared to the initial soils. The available S content of the post harvest soils ranged from 12.01 to 14.30 ppm. The highest value was recorded in T_6 treatment and the lowest value in T_0 treatment. Shahiduzzman (1997) reported that application of organic fertilizers increased available S content in soil compared to application of inorganic fertilizers.

Conclusion

Combined application of fertilizer along with cowdung, poultry manure and urban wastes performed better in respect of nutrient uptake by grain and straw than that of urea nitrogen alone. Nitrogen of the rate of 47.5 kg along with PKS and poultry manure at the rate of 9.5 t/ha performed best in most of the nutrient uptake by rice and straw. Among the organic sources, poultry manure performed best in nutrient uptake by rice. Organic manuring insignificantly increased organic matter, total N, available P, exchangeable K and available S contents in post harvest soil compared to initial soil. The result should that 47.5 kg N along with PKS and poultry manure at the rate of 4.75t/ha may be suitable dose for higher yield of boro rice. Cowdung or urban wastes at the rate of 5.75 t/ha, respectively could be applied in boro rice if poultry manure is not available.

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EFFECTS OF NITROGEN AND BORON ON THE YIELD AND HOLLOW STEM DISORDER OF BROCCOLI

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Abstract

A field experiment was conducted at Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh during winter season 2003-2004 to determine the role of N and B on the yield and hollow stem disorder of broccoli and to determine the optimum dose of N and B for broccoli production as well as to control hollow stem disorder. The experiment was conducted with four levels of N as 0, 60,120, 180 kg ha^{-1} and four levels of B as 0, 0,5, 1.0 and 1.5 kg ha^{-1} as treatment variables. Applied N and B had significant impact on the yield and hollow stem disorder of broccoli. The highest curd yield (15.14 t ha^{-1}) was found with the maximum rate of N (180 kg ha¯1) and the incidence of hollow stem disorder was increased by increasing rate of N application attaining the highest value of hollow stem index (1.39) with 180 kg N ha^{-1}. The curd yield of broccoli was increased with the boron application up to 1.0 kg ha^{-1} and showed a remarkable impact on reduction of hollow stem disorder. A moderately high amount of B application (1.0 kg ha^{-1} has led to the minimum incidence of hollow stem disorder attaining considerably lowest value of hollow stem index of 1.00 as against the maximum value of 1.16 under no application of B. The interaction effect of N and B on yield and quality of broccoli was significant and the highest curd yield (16.68 t ha¯1) was recorded under 180 kg N and 1.0 kg B ha^{-1}, which may be considered to be the optimum doses for achieving satisfactory yield and controlling hollow stem disorder of broccoli in Shallow-Red-Brown Terrace Soil of Madhupur Tract.

Introduction

Broccoli (*Brassica oleracea* var. *Italica L. Cymosa Lam.*) is an important vitamin rich winter vegetable. It is a member of Cole crops belongs to the family Cruciferae. It is fairly rich in carotene and ascorbic acid and contains appreciable quantities of thiamin, riboflavin, niacin and iron (Thompson and Kelly, 1985). Successful production of broccoli depends on various factors of which fertilizer application is the most important one. Hollow stem disorder is a major problem to broccoli production which is responsible to yield reduction is commonly associated with B deficiency (Shelp *et al.,* 1992) as well as higher nitrogen rates (Babik and Elkner, 1999). More N application to soil resulted in decreased take up of B by the crops (Kotur, 1997). The incidence of hollow stem is increased by increasing application of nitrogen fertilizer (Cutcliffe, 1972; Hipp, 1974). Boron deficiency causes many anatomical, physiological and biochemical changes. It was reported by Lent and Scarchuk (1954) that stem hollowing in the brassicas has long been associated with B deficiency. According to Bradford (1975), boron deficiency is associated with hollow stem disorder in cauliflower, where nitrogen application at higher rates is known to aggravate the problem. Broccoli cultivar Premium Crop

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is a susceptible variety to boron deficiency as well as hollow stem disorder (Shattuck and Shelp (1987)). Therefore, nitrogen and boron management is a crucial factor for yield and quality as well as to control hollow stem disorder of broccoli. So, the study was undertaken to determine the role of N and B on yield and hollow stem disorder of broccoli and to determine the optimum doses of N and B for broccoli production as well as to control hollow stem disorder.

Materials and Methods

The experiment was conducted at the research farm of Bangabandhu Sheikh Muzibur Rahman Agricultural University (BSMRAU), Gazipur, Bangladesh, during November 17, 2003 to February 13, 2004. The soil of the experimental site was silty clay loam in texture having the bulk density 1.40 g cm^{-3} which belongs to Salna series of Shallow Red-Brown Terrace Soil under Agro-Ecological Zone Madhupur Tract (AEZ 28). Some chemical properties of the soil are presented in Table 1.

Table 1. Some chemical properties of the soil of experimental site

Chemical properties	Analytical results	Critical values
Soil pH	6.4	-
Total N (%)	0.11	0.12
Organic carbon (%)	1.146	C:N= 10:1
C:N ratio	10.42	10:1
Boron (µg/g soil)	0.455	0.2
Available P (µg/g soil)	25.583	10.0
Exchangeable K (meq/100g soil)	0.363	0.12
Available S ((µ g/g soil))	44.32	10.0
Total Zn (µg/g soil)	3.25	0.6
Exchangeable Ca (meq/100g soil)	7.448	2.0
Exchangeable Mg (meq/100g soil)	2.21	0.5
CEC (meq/100g soil)	11.908	-

The Experiment was carried out in a split-plot design with three replications. Four levels of nitrogen 0, 60, 120 and 180 kg N ha^{-1} were assigned in the main plots and four levels of boron 0, 0.5, 1.0 and 1.5 kg B ha^{-1}in sub-plots. The row to row and plant to plant distance was 60 and 45 cm, respectively. All other fertilizers were applied uniformly as a blanket dose for all treatment at the rate of 53P:83K:20S:2Zn: 0.8 Mo kg ha^{-1}. Twenty five day-old healthy seedlings of broccoli (var. Italica L. cv. Premium Crop) were transplanted in the experimental plot on 17 November, 2003. All the fertilizers except urea and MoP were applied as basal and were incorporated into the soil during final land preparation. Urea and MoP were applied in two equal splits at 15 and 30 DAT followed by ring method around the plant bases. At an early stage, sprinkler irrigation was applied and at later stages irrigation water was applied in the furrows at an interval of 7 days. Necessary intercultural operations and weeding were done properly. Crop harvesting was started on 17th January and continued up to 28th January.

Data on different plant parameters were recorded from 10 randomly selected plants located at the middle of each plot leaving adequate border plants. Similar number of plants and curds were observed for determination of yield and hollow stem disorder. The crop was harvested when the curd/inflorescence attained at commercial maturity (13-15 cm in diameter and just started to swell but before opening the flower bud). The weight of individual curd was taken including the stalk with three young leaves and the marketable portion of the plant was considered to the extent of about 15 cm from the top of the inflorescence along the stem (Liu *et al.*, 1993). Hollow stem index (HI) was determined by the methodology followed by Shattuck and Shelp (1987) and was rated through visual inspection of longitudinal section of the stalk

and head. Accordingly, the incidence of hollow stem was observed at the stem base of heads, 15-18 cm in length according to Shattuck *et al.* (1986) and was expressed as hollow stem index (HI) as stated by Shattuck and Shelp (1987). Each longitudinal head section was scored according to the scale: 0 = hollow stem absent, 1 = slight hollow stem, 2 = moderate hollow stem and 3 = severe hollow stem.

The hollow stem index (HI) for each replication was calculated using the following equation:

$$HI = \sum_{i=0}^{3} n_i X_i / N$$

Where,
n_i = number of plants in the ith scale class
X_i = the ith scale value and
N = total number of plants scored.

The highest index indicates the most severe case of hollow stem disorder and the lowest indicates the least hollow stem disorder. Data were analyzed statistically by using a computer program "MSTATC". The values of hollow stem index were converted to a degree by squire root transformation prior to analysis to bring homogeneity and additivity. The treatment comparison was made followed by Duncan's Multiple Range Test (DMRT) at 5% level of probability. Correlation co-efficient and regression analysis were done using Microsoft Excel program.

Results and Discussion

Effect of N on different plant parameters, curd yield and hollow stem index

Plant height

A significant effect of N was found on plant height. It was increased with the increasing rate of N application and the highest plant height (70.68 cm) was recorded with 180 kg N ha^{-1} and it was significantly different from all other treatments (Table 2). Minimum plant height was found from the treatment without N fertilizer. Nitrogen application at the rate of 60, 120 and 180 kg ha^{-1} in presence of other elements showed 20.6, 23.3 and 28.6% higher plant height over control. Higher amount of nitrogen application had led to better vegetative growth of plants to attain the highest plant height. This result was supported by Letey *et al.* (1983).

Stem diameter

The diameter of the stem varied significantly with different levels of N fertilizer. It was increased with the increasing rate of N upto 180 kg ha^{-1} (Table 2) and the maximum diameter (5.83 cm) was recorded from 180 kg N ha^{-1} which was statistically similar to 120 kg N ha^{-1}. Minimum stem diameter (3.90 cm) was found from the treatment without N fertilizer.

Curd diameter

The shape of the main curd is a genetic character. The cultivar used in the experiment had round head. The curd diameter in this cultivar can be considered as an appropriate measure of curd size. The curd diameter was increased significantly with increasing rate of N fertilizer (Table 2). The highest dose of N (180 kg ha^{-1}) produced the maximum curd diameter (15.02 cm) which was statistically similar to those obtained from the levels 120 and 60 kg N ha^{-1}. The lowest curd diameter (9.15 cm) was recorded from the plot where N was not applied. The

increment of curd diameter was 64.15 and 54.64% under application of 180 and 120 kg N ha^{-1}, respectively as compared to 0 kg N ha^{-1}. This result is very close to the findings of Thompson and Kelly (1985).

Curd yield

There was a significant response of curd yield (t ha^{-1}) of broccoli to different levels of N fertilizer. Curd yield increased significantly with the incremental doses of N application (Table 2). The highest yield of 15.14 t ha^{-1} was recorded under the highest rate of N application (180 kg ha^{-1}) which was significantly different from all other treatments. The rate of increased curd yield of broccoli by application of 180, 120 and 60 kg N ha^{-1} over the control treatment (0.0 kg N) were 254.57, 171.66 and 59.25 %, respectively, thus signifying the indispensability of higher doses of N application for achieving better yield of broccoli.

Hollow stem index (HI)

The hollow stem index (HI) recorded from the experiment was significantly influenced by the different levels of N (Table 2). It was revealed that the hollow stem index of broccoli was favored by increasing rate of N application and the maximum severity of hollow stem disorder (HI-1.389) was noted under the application of highest dose of N (180 kg N ha^{-1}) which was significantly higher than those of any other treatments. The intensity of this disorder decreased significantly with decrease in N rate and was attained to the minimum value of 0.742 with no application of N. It was found from the observation that increased rate of N application have increased the vegetative growth of plants and the turgidity of plant cells that might have led to hollowness in the stem.

Effect of B on different plant parameters, curd yield and hollow stem index

Plant height

The effect of B on plant height was also found significant (Table 2). In that case, plant height was significantly influenced by the different levels of B and it was gradually increased up to the rate 1.0 kg B ha^{-1} and then decreased. The maximum plant height (65.72 cm) was noted from the treatment receiving B at the rate of 1.0 kg ha^{-1} which was statistically similar to 0.5 and 1.5 kg B ha^{-1}. The minimum plant height (63.50 cm) was found from the treatment without B. Sharma and Arora (1984) reported the maximum plant height from 2.5 kg B ha^{-1} in cauliflower which relates this findings.

Stem diameter

Stem diameter was increased with increasing rate of B up to 1.0 kg ha^{-1} and then decreased (Table 2). The higher dose of B (1.0 kg ha^{-1}) produced the maximum stem diameter (5.32 cm) which was statistically similar to 1.5 and 0.5 kg B ha^{-1}. The lowest stem diameter (4.70 cm) was recorded from the treatment without B. Application of higher levels of B led to an increase in stem diameter of broccoli but it was increased up to a certain limit and then declined.

Curd diameter

Curd diameter was significantly increased by B application but there was no significant variation among B added plots (Table 2). The maximum curd diameter (13.32 cm) was recorded under application of 1.5 kg B ha^{-1} followed by 1.0 kg B ha^{-1} which produced a curd diameter of

13.31 cm. The minimum diameter was found in treatment where no B was added. This result was related to Sanjoy *et al.* (2002) as they opined that Mo and B application significantly increased the curd diameter, weight and yield of cauliflower.

Curd yield

Curd yield was also significantly increased by adding B to soil up to 1.5 kg ha^{-1} (Table 2). Higher curd yield (10.25 t ha^{-1}) was obtained from1.5B kg ha^{-1}, which was statistically similar to 1B kg ha^{-1} (10.15 t ha^{-1}). The minimum yield (8.23 t ha^{-1}) was recorded from the B level 0 kg ha^{-1}. Boron application at the rate of 1.5, 1.0 and 0.5 kg gave 24.54, 23.37 and 11.54 % higher curd yield, respectively over control.

Hollow stem index (HI)

Hollow stem index was also significantly influenced by different B level. It was decreased with the increase in B level up to 1.0 kg ha^{-1} and then increased (Table 2). The highest hollow stem index (1.161) was found from the B level 0 kg ha^{-1}, which was significantly different from all other B levels. The minimum hollow stem index (1.003) was noted from 1B kg ha^{-1}. It means that increase of B level up to a certain limit may decrease the hollow stem disorder.

Table 2. Effect of N and B on different plant parameters, curd yield and hollow stem index of broccoli

Treatment	Plant height at maturity (cm)	Stem diameter (cm)	Curd diameter (cm)	Curd yield (t/ha)	Hollow stem index (HI)
N level (kg ha^{-1})					
0	54.95 c	3.90 c	9.146 c	4.270 d	0.742d
60	66.25 b	4.96 b	12.76 b	6.802 c	0.930c
120	67.78 b	5.74 a	14.15 ab	11.601b	1.261b
180	70.68 a	5.83 a	15.02 a	15.140 a	1.389a
SE (±)	0.79	0.14	0.56	0.20	0.03
CV (%)	2.77	6.44	6.29	5.67	6.49
B level (kg ha^{-1})					
0	63.50 b	4.70 b	11.76 b	8.230 c	1.161a
0.5	64.95 ab	5.14 a	12.70 a	9.180 b	1.076b
1.0	65.72 a	5.32 a	13.31 a	10.153 a	1.003c
1.5	65.50 a	5.27 a	13.32 a	10.247 a	1.081b
SE (±)	0.53	0.10	0.23	0.16	0.02
CV (%)	2.77	6.44	6.29	5.67	6.49

Results followed by the common letters are not significantly different from each other at 5% level of significance by DMRT

Interaction between N and B on different plant parameters, curd yield and hollow stem index

The interaction effects of N and B on plant height, stem diameter and curd diameter of broccoli was found insignificant. But curd yield of broccoli was significantly influenced by the combined effect of N and B application (Table 3). It was revealed that curd yield was increased with the increasing rate of N application but it was increased with B up to 1.0 kg B ha^{-1} and then decreased with further incremental rate of B application. The highest curd yield (16.68 t ha^{-1}) was obtained from the combined dose of 180 N: 1B kg ha^{-1} which was significantly different from all other treatment combinations. Mishra and Singh (1984) found the similar interaction effect on this character in cauliflower. This might be due to the higher crop growth with high accumulation and translocation of photosynthetic materials to the curd. From above discussion, it may be ascertained that the combined dose of N and B application at the rate of 180 kg N

along with 1.0 kg B ha^{-1} are the optimum dose to be applied to soil for getting maximum yield of broccoli.

Similarly a significant interaction effect of N and B was found on the hollow stem index (HI) of broccoli (Table 3). The maximum hollow stem index (1.549) was recorded from the combination of 180 N: 0 B kg followed by 180 N: 1.5 B kg, and 120 N: 0 B kg which were statistically similar to each other and the minimum HI (0.707) was found from the combination of 0N: 0 B kg. It was revealed that increasing rate of N also increased the hollow stem index under each B level. It was observed that within N level 180 kg ha^{-1}, hollow stem index decreased up to 1.0 kg B level and then it was increased. The intensity of this disorder decreased significantly with decrease in N rate and was attained to the minimum value of 0.707 with no application of N and B. But, increase in B level up to a certain limit with higher doses of N, decreased the hollow stem disorder. It revealed from the observation that increased rate of N application positively increased the vegetative growth of plants and the turgidity of plant cells that might have led to hollowness in the stem. Both yield and curd quality was affected and reduced due to the presence of hollow stem disorder. But this could be checked by using B at the rate of 1.0 kg ha^{-1} through which curd quality of broccoli was improved.

Table 3. Interaction effect of N and B on curd yield (t ha^{-1}) and hollow stem index of broccoli

Treatment	N level (kg ha^{-1})			
	Curd yield (t ha^{-1})			
B level (kg ha^{-1})	0	60	120	180
0	4.070 j	5.227 i	9.533 f	14.090 bc
0.5	4.300 ij	6.610 h	10.780 e	15.030 b
1.0	4.343 ij	7.153 h	12.440 d	16.680 a
1.5	4.367 ij	8.217 g	13.65 c	14.760 b
SE (±)	0.31			
CV (%)	5.67			
	Hollow stem index (HI)			
B level (kg ha^{-1})	0	60	120	180
0	0.7071f	0.9500 e	1.4370 ab	1.5490 a
0.5	0.7499 f	0.9417 e	1.2610 cd	1.3520 bc
1.0	0.7478 f	0.8911 e	1.1800 d	1.1950 d
1.5	0.7646 f	0.9357 e	1.1660 d	1.4590 ab
SE (±)	0.04			
CV(%)	6.49			

Results followed by the common letters are not significantly different from each other at 5% level of significance by DMRT

Correlation regression analysis results

Curd yield

From the response curve (Fig 1) it was found that the yield was highly correlated with N level showing $R^2 = 0.9876$, which indicated that maximum increase in curd yield by 99 % with the highest N level, 180 kg ha^{-1}. Research findings from the works of Gorski and Armstrong (1985), Default (1988), Kawalenko and Hall (1987), Trimblay (1989) had supported the findings of the study. Erdem *et al.* (2010) also reported that the yield of broccoli (var. Italica) was increased with increasing rate of nitrogen application. Similar results were observed by Moniruzzaman *et al.* (2007) for broccoli. It was found that the yield was highly correlated with B level depicting $R^2 = 0.9168$, which indicated that maximum increase in curd yield by 92% with the highest B level 1.5 kg ha^{-1}(Fig 2). These findings are in agreement with the results of Singh *et al.* (2002) for cauliflower with application of B up to1.0 kg ha^{-1}.

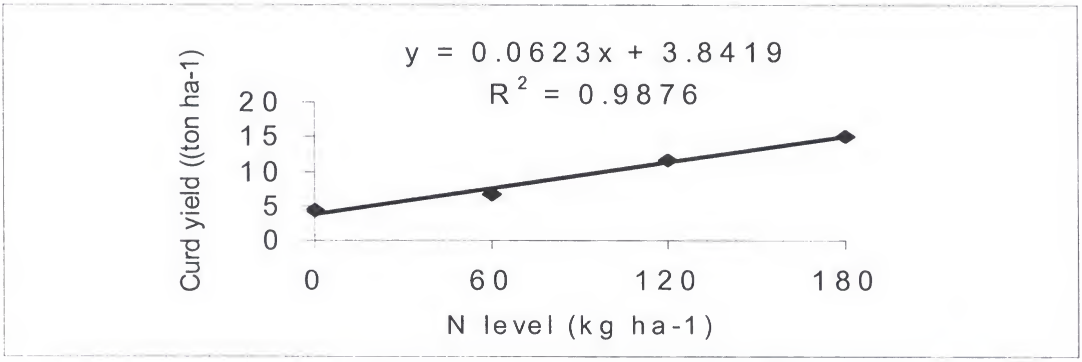

Fig. 1. Effect of different nitrogen levels on curd yield (t ha^{-1} of broccoli)

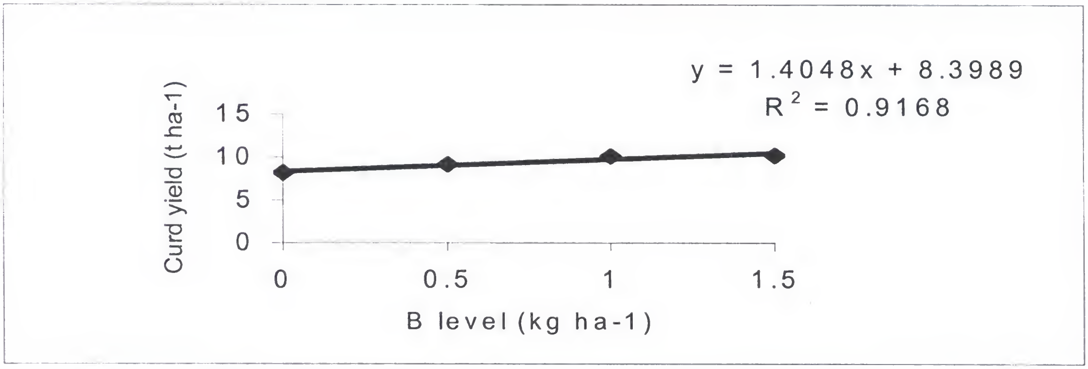

Fig. 2. Effect of different boron levels on curd yield (t ha^{-1}) of broccoli

Hollow stem index

From the response curve it was also found that the HI was highly correlated with N level and having the value of $R^2 = 0.9739$ (Fig. 3), which indicated that maximum increase in HI by 97% with the highest N level of 180 kg ha^{-1}. This result was supported by the findings of Gorski and Armstrong (1985) as stated that hollow stem in broccoli is intensified by rapid maturation and increasing N rate. It was also observed from the response curve that the HI negatively correlated with B levels having $R^2 = 0.9228$ (Fig. 4), which indicated that maximum decrease in HI by 92% with the highest B level of 1.0 kg ha^{-1}. This result supported the findings of Lent and Scarchuk (1954) mentioning that stem hollowing in the brassicas has long been associated with B deficiency. It also related to the findings of Vigier and Cutcliffe (1984) as found that a portion of the hollow stem disorder in broccoli could be attributed to B deficiency. The findings also supported by Shattuck and Shelp (1987) where they found that broccoli variety Premium Crop grown in the absence of B showed initial signs of hollow stem which was alleviated by adding B and suggested B nutrition as involved in the induction of hollow stem in broccoli. Similarly, Moniruzzaman *et al.* (2007) reported that B deficiency is associated with hollow stem disorder in broccoli.

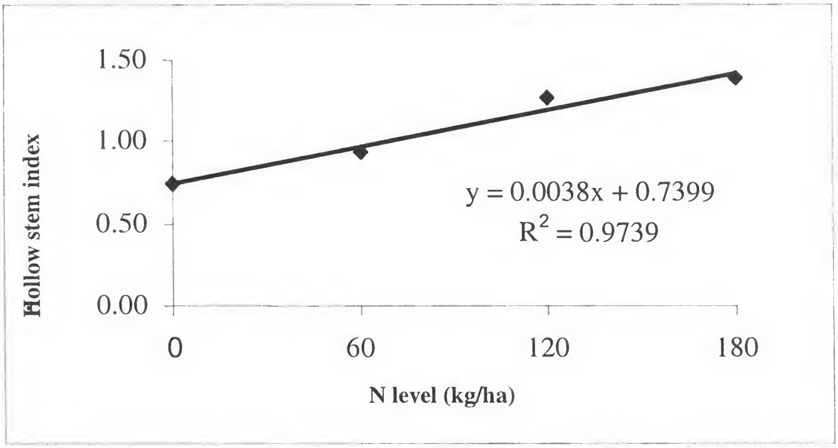

Fig. 3. Effect of different levels of N on hollow stem index of broccoli

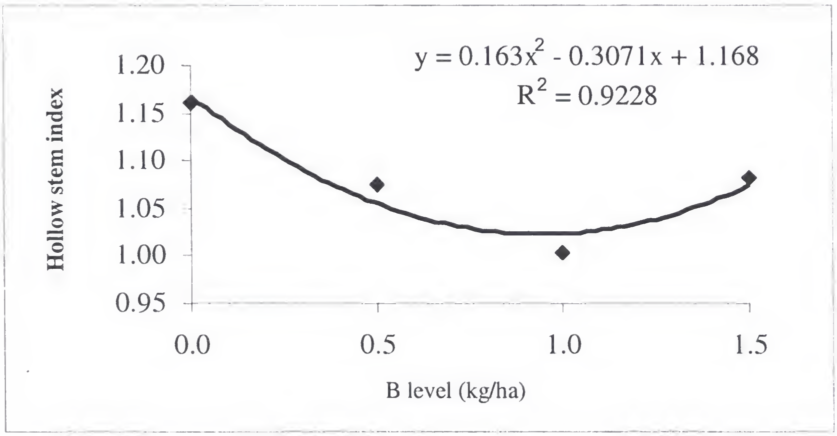

Fig. 4. Regression analysis of different levels of B on hollow stem index of broccOli

Conclusion

Based on the results of the study it could be concluded that hollow stem disorder in broccoli is favored by higher rate of N application, while B application up to 1.0 kg ha^{-1} would reduce the incidence of hollow stem without hampering the crop yield. Considering the yield and quality of broccoli, a combined application of 180 kg N with 1.0 kg B ha^{-1} has been found suitable for achieving higher yield of quality broccoli. Therefore, the combined dose of 180 kg N and 1.0 kg B/ha could be considered for achieving the maximum yield of broccoli in Shallow-Red-Brown Terrace Soil of Madhupur Tract.

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RESPONSE TO NITROGEN, PHOSPHORUS, POTASSIUM AND SULPHUR IN GROWTH AND QUALITY OF CABBAGE

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Abstract

A field experiment was carried out at Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur during October 2009 to May 2010 to evaluate the response of cabbage to N, P, K and S as the source of urea, TSP, MP and gypsum application in Salna silty clay loam soil. Treatment receiving 240N: 45 P: 180 K and 45S kg/ha performed best in respect of plant height, leaf length and breadth and thickness of head of cabbage while 240N: 45 P: 180 K: 60 S kg/ha recorded highest calcium (0.7867%) and sulphur (1.423%) content in loose leaves but magnesium (0.1700%) in the treatment of 240 N: 45 P: 180 K: 45S kg /ha. The later treatment also recorded the maximum Ca (0.6967%), Mg (0.1530%) and S (1.1830%) in heading leaves. Treatment 320 N: 45 P: 180 K: 30 S kg showed maximum iron, manganese and zinc content both in loose and heading leaves of the crop. Nitrogen (163.30 kg/ha), phosphorus (5.63 kg/ha), potassium (18.35 kg/ha) and sulphur (32.60 kg/ha) uptake by plant was the highest in treatment receiving 240 N: 45 P: 180 K and 45 S kg/ha.

Introduction

Cabbage belongs to the Cruciferae family and is related to turnips, cauliflowers and brussels sprouts. Cabbage (*Brassica oleracea* var. *capitata* L.) is one of the most important winter vegetables grown in Bangladesh which contains vitamins and minerals (Quayyum and Akanda, 1988). It is an herbaceous rapid growing vegetable. This unique vegetable has been widely grown in both tropical and temperate regions of the world (Sarker *et al*., 2002). Cabbage ranks the second position in respect of production and area among the vegetables grown in Bangladesh. Kustia, Meherpur, Jessore, Bogra and Tangail are leading cabbage growing districts in Bangladesh (Sarker *et al*., 2002). There were 12060 hectares of land under cabbage cultivation with a production of 113 thousand metric tons in the country during the year 1997-98 (Anon. 1999) with an average yield of 9.29 t/ha which is quite low in comparison with other countries of the world like South Korea (11.7 t/ha), Germany (54.61 t/ha), Japan (40.32 t/ha) and India (19.12 t/ha) (FAO, 1998).

The importance of nitrogen, phosphorus, potassium and sulphur on the growth and yield of vegetable crops is well established. Among the nutrients, nitrogen plays the most important role

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for vegetative growth of the crop. Phosphorus is also essential nutrient element which helps in the good growth of the roots of vegetable crops. Phosphorus helps in the root development and increases the efficiency of leaf in the manufacture of sugar. Potassium exerts balancing role on the effects of both nitrogen and phosphorus, consequently it is especially important in multinutrient fertilizer application (Brady, 1990). Analysis of soil samples of important soil types and series of Bangladesh reveals that 80-90% soils are poor in zinc and sulphur, while 100% soils are deficit in nitrogen (Porch and Islam, 1984). Besides this deficiency in phosphorus is now considered as one of the major constraint to successful production of upland crops (Islam and Noor, 1982). Moreover, the proportion of nutrient applied by vegetable growers in Bangladesh is not balanced. Use of imbalanced nutrients in the soils may be harmful and causing the agricultural soil degraded and unproductive (Hossain *et al.*, 2004). Thus, the nutrient deficient soils must be identified and these soils should be enriched with these nutrients through balanced use of fertilizer. Keeping these facts in mind to find out the optimum doses of N, P, K and S nutrients for sustainable growth and nutritional quality and to assess nutrient uptake by cabbage in Salna silty clay loam soil of cabbage by the application of appropriate doses of N, P, K, and S nutrients.

Materials and Methods

A field experiment was conducted at the research farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur during October 2009 to May 2010 to find out the maximum growth and quality of cabbage by the application of judicial doses of nitrogen, phosphorus, potassium and sulphur nutrients. The soil belongs to Shallow Red Brown Terrace Salna series representing the AEZ - 28 of Madhupur Tract in Bangladesh which falls under Inceptisols in Soil Taxonomy (Brammer, 1978). Soil samples of the experimental plots were collected before transplanting seedlings of cabbage from a depth of 0-15 cm and analyzed for physical and chemical properties in the Soil Science laboratory. The soil was silty clay loam in texture with a pH 6.70, bulk density 1.42 g/cc, particle density 2.59 g/cc, organic carbon 0.75%, total N 0.11%, available P 11.00 ppm, exchangeable K 0.25 meq/100 g soil, available S 9.40 ppm, available Zn 1.30 ppm and available B 0.20 ppm in the surface.

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The unit plot size was 2 m × 3 m maintaining line to line 60 cm and seedling to seedling 40 cm which were separated by 0.5 m drain. The plots were raised by 30 cm by raising soil from the drain. There were eighteen treatment combinations selected on the basis of nutrient status of the initial soil of the experimental field viz. $T_1 = N_0P_{45}K_{180}S_{30}$, $T_2 = N_{80}P_{45}K_{180}S_{30}$, $T_3 = N_{160}P_{45}K_{180}S_{30}$, $T_4 = N_{240}P_{45}K_{180}S_{30}$, $T_5 = N_{320}P_{45}K_{180}S_{30}$, $T_6 = N_{240}P_0K_{180}S_{30}$, $T_7 = N_{240}P_{15}K_{180}S_{30}$, $T_8 = N_{240}P_{30}K_{180}S_{30}$, $T_9 = N_{240}P_{60}K_{180}S_{30}$, $T_{10} = N_{240}P_{45}K_0S_{30}$, $T_{11} = N_{240}P_{45}K_{60}S_{30}$, $T_{12} = N_{240}P_{45}K_{120}S_{30}$, $T_{13} = N_{240}P_{45}K_{240}S_{30}$, $T_{14} = N_{240}P_{45}K_{180}S_0$, $T_{15} = N_{240}P_{45}K_{180}S_{15}$, $T_{16} = N_{240}P_{45}K_{180}S_{45}$, $T_{17} = N_{240}P_{45}K_{180}S_{60}$ and $T_{18} = N_0P_0K_0S_0$ kg/ha.

The soil was well prepared by deep ploughing with tractor followed by harrowing and laddering up to a good tilth. The experimental plot was laid in south north facing and all weeds and stubbles were removed. The individual plots were made by making ridges (25 cm height) from the soil surface. Ridges were made around each plot to restrict the lateral run off irrigation water. The hybrid variety Autumn Queen of cabbage was used. The required fertilizers were added to the individual plot. Ten plants were selected randomly from each plot for data

collection at the mature stage. The mature stage was determined visually by seeing the opening of two outside inner leaf. Dried loose and heading leaves were ground and processed for determination of N, P, K, Ca, Mg, S, Fe, Mn and Zn contents. The recorded data on various parameters of the crop were statistically analyzed and the differences between the treatment means were compared by Duncan's Multiple Range Test (DMRT).

Results and Discussion

Plant height

The effect of nitrogen, phosphorus, potassium and sulphur on plant height of cabbage was significant (Table 1). The maximum plant height (37.47 cm) was recorded by the treatment T_{16} receiving 240 N: 45 P: 180 K: 45 S kg/ha. The increased plant height in broccoli by the application of 240 N: 100 P: 80 K kg/ha also reported by Moniruzzaman *et al.* (2006). Similar results were shown by Sarker *et al.* (2002) in cabbage. The effect of this treatment was statistically similar to all other treatments except T_1, T_2, T_3, T_6, T_{10}, T_{14} and T_{18}. The minimum height of plant (16.44 cm) was found in control plots. The results are in agreement with those of Anwar *et al.* (2001). They observed that plant height was (37.70, 40.50 cm) by the application of 34 P:66 K:20 S: 1 Mo kg/ha. Sarker *et al.* (1996) noted significant difference in plant height of cabbage due to different sources of nutrients. Kacjan Marsic and Osvald (2004) found that plant height of white cabbage was significantly increased when 30% of total N was pre-plant incorporated and remaining N and total amounts of P and K were applied via fertigation.

Leaf length

Leaf length had significantly influenced by different doses of nutrients (Table 1). The maximum leaf length (34.36 cm) was noted by T_{16} receiving 240 N: 45 P: 180 K:45 S Kg/ha which was statistically similar to T_4, T_7, T_8, T_9, T_{11}, T_{12}, T_{13}, T_{15} and T_{17}. This might be due to the favourable influence of nitrogen, phosphorus, potassium and sulphur resulting increased leaf length of cabbage. The minimum value (19.08 cm) was observed in T_{18} (control) treatment. Anwar *et al.* (2001) recorded significantly increased leaf length of broccoli with the increasing rates of nitrogen upto 150 kg/ha along with 34 P: 66 K: 20S: 1 kg Mo: 5 Zn Kg /ha plus 5 t/ha cowdung.

Leaf breadth

Different nutrient levels significantly influenced leaf breadth of cabbage (Table 1). The maximum leaf breadth (27.00 cm) was recorded in T_{16} treatment which was similar to T_4 and T_8 treatments and the minimum leaf breadth (14.17 cm) was obtained in control treatment (T_{18}). The effects of treatments T_3, T_7, T_8, T_9, T_{11}, T_{12} and T_{17} were similar in recording leaf breadth of cabbage. Leaf breadth significantly increased up to 240 N: 45 P: 180 K: 45 S Kg/ha. Further, increasing nutrient levels decreased leaf breadth of cabbage. Moniruzzaman *et al.* (2006) reported significantly higher leaf breadth of broccoli with 240 N,: 43 P: 66K Kg/ha.

Thickness of head

There was a significant effect of different levels of nutrients in recording thickness of cabbage (Table 1). The maximum thickness of head (12.62 cm) was recorded in T_{16} treatment which was statistically similar to the rest of the treatments except T_1, T_2, T_3, T_6, T_{10}, T_{14}, T_{15}, T_{17} and T_{18}. The minimum thickness (7.04 cm) was recorded in T_{18} (control) treatment. Application

of different combinations of nutrients (T_{16}) led to 79.26% higher thickness of head over control treatment. Thickness of head significantly increased with the increase of N from 0 to 240 kg, P from 0 to 45 kg, K from 0 to 180 kg and S from 0 to 45 kg/ha. Sarker *et al.* (2002) reported that the maximum thickness of head of cabbage (14.55 cm) was noted with organic + inorganic fertilizer application.

Table 1. Effects of different doses (kg/ha) of nutrients on plant height, leaf length, leaf breadth and thickness of head of loose and heading leaves of cabbage

Treatments	Plant height (cm)	Leaf length (cm)	Leaf breadth (cm)	Thickness of head (cm)
$T_1 = N_0P_{45}K_{180}S_{30}$	27.80c	24.78cd	19.67h	9.77d
$T_2 = N_{80}P_{45}K_{180}S_{30}$	30.90bc	26.20bc	23.94cd	10.70bcd
$T_3 = N_{160}P_{45}K_{180}S_{30}$	30.95bc	26.70bc	25.17bc	10.72bcd
$T_4 = N_{240}P_{45}K_{180}S_{30}$	37.22a	32.78ab	26.66a	12.17ab
$T_5 = N_{320}P_{45}K_{180}S_{30}$	33.71ab	26.50bc	22.28ef	11.23abcd
$T_6 = N_{240}P_0K_{180}S_{30}$	30.89bc	24.85cd	20.67gh	10.44cd
$T_7 = N_{240}P_{15}K_{180}S_{30}$	35.30ab	28.22abc	24.67bc	11.67abc
$T_8 = N_{240}P_{30}K_{180}S_{30}$	36.72a	31.01abc	26.04ab	11.97abc
$T_9 = N_{240}P_{60}K_{180}S_{30}$	33.92ab	27.66abc	24.70bc	11.39abc
$T_{10} = N_{240}P_{45}K_0S_{30}$	30.70bc	26.14bc	20.83fgh	10.50cd
$T_{11} = N_{240}P_{45}K_{60}S_{30}$	33.60ab	27.34abc	24.65bc	11.70abc
$T_{12} = N_{240}P_{45}K_{120}S_{30}$	35.44ab	28.35abc	24.81bc	11.80abc
$T_{13} = N_{240}P_{45}K_{240}S_{30}$	34.75ab	28.08abc	24.03cd	11.58abc
$T_{14} = N_{240}P_{45}K_{180}S_0$	30.97bc	26.73bc	21.17fg	10.60cd
$T_{15} = N_{240}P_{45}K_{180}S_{15}$	33.55ab	27.07abc	21.72efg	10.65bcd
$T_{16} = N_{240}P_{45}K_{180}S_{45}$	37.47a	34.36a	27.00a	12.62a
$T_{17} = N_{240}P_{45}K_{180}S_{60}$	33.03ab	27.00abc	24.68bc	10.75bcd
$T_{18} = N_0P_0K_0S_0$	16.44d	19.08d	14.17i	7.04e
CV (%)	7.25	5.46	3.54	8.75

Means in a column followed by same letter (s) are not significantly different at 5% level of significance by DMRT

Calcium content in loose leaves

There was a significant difference in recording calcium content of loose leaves of cabbage due to the application of nitrogen, phosphorus, potassium and sulphur (Table 2). Treatment T_{17} receiving 240 N: 45 P: 180 K: 60 S kg/ha recorded the maximum calcium content in loose leaves (0.7867%) which was statistically superior to the rest of the treatments. The lowest calcium content (0.3200%) in loose leaves was found in control treatment (T_0). Different levels of nitrogen, phosphorus, potassium and sulphur significantly affected calcium content in loose leaves. However, treatment T_{17} led to increase 145.84% higher calcium content than absolute control treatment (T_{18}). Wiebe *et al.* (1977) found greater Ca accumulation in loose leaves of cabbage (*Brassica oleracea* var. *capitata* L.) when compared to the heading leaves. The author attributes high Ca accumulation with greater transpiration rates in loose leaves of cabbage.

Magnesium content in loose leaves

Magnesium content in loose leaves was significantly influenced by different levels of nutrients (Table 2). The highest magnesium content in loose leaves (0.1700%) was noted in T_{16} treatment which was statistically similar to all the treatments except T_{18}. Higher magnesium content in loose leaves might be due to favourable influence of nitrogen, phosphorus, potassium and sulphur in cabbage. The lowest magnesium (0.1520%) content in loose leaves was noted in absolute control treatment.

Sulphur content in loose leaves

Different levels of nutrients markedly influenced sulphur content in loose leaves of cabbage (Table 2). Gradual increment in sulphur level along with nitrogen, phosphorus and potassium nutrients significantly increased sulphur content in loose leaves of cabbage. This might be due to the favaourable influence of sulphur nutrients along with nitrogen, phosphorus and potassium resulting higher content of sulphur. Application of 240 N: 45 P:180 K:60 S kg/ha (T_{17}) recorded the highest sulphur content in loose leaves which was statistically similar to T_{16} treatment but superior to the rest of the treatments. The lowest sulphur content in loose leaves was found in absolute control treatment (T_{18}).

Iron content in loose leaves

Iron content in loose leaves was markedly influenced by different levels of nutrients (Table 2). The highest iron content (0.4133%) in loose leaves was noted in T_5 treatment which was statistically similar to all the treatments except T_1, T_2, T_6, T_{10} and T_{18} treatments. The lowest iron content (0.2767%) was found in T_{18} (Control) treatment.

Manganese content in loose leaves

There were significant variations among the treatments in respect of manganese content in loose leaves of cabbage (Table 2). The maximum manganese content in loose leaves (0.3500%) was observed in T_5 treatment which was statistically similar to all treatments except T_1, T_2, T_3, T_{10}, T_{14} and T_{18}. The lowest manganese content (0.1820%) in loose leaves was attained in absolute control treatment (T_{18}).

Zinc content in loose leaves

Zinc content in loose leaves was significantly influenced by different levels of nutrients (Table 2). The maximum zinc content (0.0350%) in loose leaves was found in T_5 receiving 320 N: 45 P: 180: K: 30 S Kg/ha which was statistically similar to all the treatments except T_{18}. The minimum zinc content (0.0260%) in loose leaves was found in control (T_{18}) treatment.

Table 2. Effects of different doses (kg/ha) of nutrients on calcium, magnesium, sulphur, iron, manganese and zinc content in loose leaves of cabbage

Treatments	Ca content (%)	Mg content (%)	S content (%)	Fe content (%)	Mn content (%)	Zn content (%)
$T_1 = N_0P_{45}K_{180}S_{30}$	0.4600d	0.1580ab	0.671h	0.3050b	0.1980c	0.0280ab
$T_2 = N_{80}P_{45}K_{180}S_{30}$	0.5467c	0.1667a	1.023cd	0.3010b	0.2025b	0.0280abc
$T_3 = N_{160}P_{45}K_{180}S_{30}$	0.5567c	0.1600ab	1.077c	0.3533ab	0.2000b	0.0280abc
$T_4 = N_{240}P_{45}K_{180}S_{30}$	0.5467c	0.1633ab	1.053cd	0.3467ab	0.2900a	0.0290ab
$T_5 = N_{320}P_{45}K_{180}S_{30}$	0.5400c	0.1625ab	0.950def	0.4133a	0.3500a	0.0350a
$T_6 = N_{240}P_0K_{180}S_{30}$	0.4100d	0.1629ab	0.836g	0.3020b	0.3000a	0.02920ab
$T_7 = N_{240}P_{15}K_{180}S_{30}$	0.5900c	0.1633ab	1.027cd	0.3567ab	0.2955a	0.0293ab
$T_8 = N_{240}P_{30}K_{180}S_{30}$	0.5733c	0.1624ab	1.010cd	0.3367ab	0.2933a	0.0293ab
$T_9 = N_{240}P_{60}K_{180}S_{30}$	0.5533c	0.1599ab	0.976cde	0.3633ab	0.3100a	0.0290ab
$T_{10} = N_{240}P_{45}K_0S_{30}$	0.4067d	0.1590ab	0.866fg	0.3030b	0.2180b	0.0291ab
$T_{11} = N_{240}P_{45}K_{60}S_{30}$	0.5733c	0.1667a	0.950def	0.3600ab	0.3033a	0.0330a
$T_{12} = N_{240}P_{45}K_{120}S_{30}$	0.5367c	0.1667a	1.183b	0.3533ab	0.2833a	0.0280abc
$T_{13} = N_{240}P_{45}K_{240}S_{30}$	0.5900c	0.1567ab	1.043cd	0.3533ab	0.2933a	0.0290ab
$T_{14} = N_{240}P_{45}K_{180}S_0$	0.3333e	0.1620ab	0.683h	0.3533ab	0.2200b	0.0290ab
$T_{15} = N_{240}P_{45}K_{180}S_{15}$	0.4133d	0.1626ab	0.900efg	0.3600ab	0.2900a	0.0296ab
$T_{16} = N_{240}P_{45}K_{180}S_{45}$	0.7612b	0.1700a	1.397a	0.3600ab	0.3400a	0.0296ab
$T_{17} = N_{240}P_{45}K_{180}S_{60}$	0.7867a	0.1670a	1.423a	0.3167ab	0.3067a	0.0346a
$T_{18} = N_0P_0K_0S_0$	0.3200e	0.1520b	0.453i	0.2767b	0.1820c	0.0260b
CV (%)	5.81	10.01	6.61	10.38	4.22	9.72

Means in a column followed by same letter (s) are not significantly different at 5% level of significance by DMRT

Calcium content in heading leaves

Calcium content in heading leaves was significantly influenced by different levels of nitrogen, phosphorus, potassium and sulphur nutrients (Table 3). The highest calcium content in heading leaves (0.7300%) was noted in T_{17} which was statistically similar to T_{16} but superior to the rest of the treatments. This might be due to the influence of sulphur fertilizer as gypsum which contains calcium that led to increase calcium content in the heading leaves of cabbage. The lowest calcium content (0.0533%) was found in absolute control treatment (T_{18}).

Magnesium content in heading leaves

The effects of different levels of nitrogen, phosphorus, potassium and sulphur nutrients on magnesium content in heading leaves are presented in Table 3. There were significant variations among the treatments in respect of magnesium content in heading leaves. The highest magnesium content in heading leaves (0.1530%) was noted in T_{16} treatment which was statistically similar to all the treatments except T_1, T_2, T_{10}, T_{14} and T_{18}. The lowest magnesium content (0.1300%) in heading leaves was observed in control (T_{18}).

Sulphur content in heading leaves

Different nutrients significantly influenced sulphur content in heading leaves of cabbage (Table 3). The highest sulphur content (1.2000%) in heading leaves was attained in T_{17} treatment which was statistically similar to T_{16} but superior to the rest of the treatments. The higher sulphur content in heading leaves was found in T_{17} might be due to the prevalence of comparatively higher supply of sulphur from previously applied gypsum fertilizer. The lowest sulphur content (0.2567%) in heading leaves was found in control (T_{18}).

Iron content in heading leaves

Different treatments reflected significantly in terms of iron content in heading leaves of cabbage (Table 3). The highest iron content (0.300%) in heading leaves was noted in T_5. The effect of this treatment was statistically similar to all the treatments except T_1 and T_{18} treatments. This might be due to the application of higher dose of chemical nitrogen fertilizer which might have increased acidity result higher solubility as well as more iron content in heading leaves of the crop. The lowest iron content (0.2010%) in heading leaves was found in control (T_{18}).

Manganese content in heading leaves

The effects of different nutrients on manganese content in heading leaves of cabbage were significant (Table 3). The maximum manganese content (0.2333%) in heading leaves was noted in T_5 treatment. The effect of treatment T_5 was however, statistically similar to all the treatments except T_1, T_2, T_3 and T_{18} treatments. This might be due to the higher dose of inorganic nitrogen fertilizer which might fall of soil pH result higher solubility as well as more manganese content in heading leaves of the crop. The lowest manganese content (0.1710%) was found in T_{18} (control) treatment.

Zinc content in heading leaves

Application of different levels of nutrients influenced zinc content in heading leaves of cabbage (Table 3). The highest zinc content (0.0315%) in heading leaves was recorded in T_5

treatment which was statistically similar to all the treatments except T_1 and T_{18} treatments. The lowest zinc content (0.0212%) in heading leaves was found in control treatment (T_{18}).

Table 3. Effects of different doses (kg/ha) of nutrients on calcium, magnesium, sulphur, iron, manganese and zinc content in heading leaves of cabbage

Treatments	Ca content (%)	Mg content (%)	S content (%)	Fe content (%)	Mn content (%)	Zn content (%)
$T_1 = N_0P_{45}K_{180}S_{30}$	0.1500g	0.1390b	0.5167h	0.2204bc	0.1800b	0.022b
$T_2 = N_{80}P_{45}K_{180}S_{30}$	0.2167defg	0.1400b	0.7800cde	0.2550ab	0.1804b	0.0263ab
$T_3 = N_{160}P_{45}K_{180}S_{30}$	0.2433def	0.1420ab	0.8600bcd	0.2567ab	0.1805b	0.0260ab
$T_4 = N_{240}P_{45}K_{180}S_{30}$	0.2533def	0.1422ab	0.8667bc	0.2600ab	0.2133ab	0.0263ab
$T_5 = N_{320}P_{45}K_{180}S_{30}$	0.2700d	0.1423ab	0.7567def	0.3000a	0.2333a	0.0315a
$T_6 = N_{240}P_0K_{180}S_{30}$	0.1833efg	0.1392ab	0.6267g	0.2560ab	0.2200ab	0.0260ab
$T_7 = N_{240}P_{15}K_{180}S_{30}$	0.2533def	0.1430ab	0.7867cde	0.2500ab	0.2200ab	0.0283ab
$T_8 = N_{240}P_{30}K_{180}S_{30}$	0.2667de	0.1432ab	0.8433bcd	0.2540ab	0.2133ab	0.0246ab
$T_9 = N_{240}P_{60}K_{180}S_{30}$	0.2633def	0.1430ab	0.7933cd	0.2267abc	0.2200ab	0.0263ab
$T_{10} = N_{240}P_{45}K_0S_{30}$	0.1800fg	0.1398b	0.6333g	0.2510ab	0.2210ab	0.0263ab
$T_{11} = N_{240}P_{45}K_{60}S_{30}$	0.3567c	0.1430ab	0.6700fg	0.2200abc	0.2133ab	0.0266ab
$T_{12} = N_{240}P_{45}K_{120}S_{30}$	0.4467b	0.1432ab	0.8967b	0.2167abc	0.2100ab	0.0260ab
$T_{13} = N_{240}P_{45}K_{240}S_{30}$	0.4567b	0.1428ab	0.6867efg	0.2300abc	0.2067ab	0.0260ab
$T_{14} = N_{240}P_{45}K_{180}S_0$	0.0666h	0.1391b	0.7867cde	0.2500ab	0.2215ab	0.0250ab
$T_{15} = N_{240}P_{45}K_{180}S_{15}$	0.2000defg	0.1422ab	0.5867gh	0.2530ab	0.2067ab	0.0263ab
$T_{16} = N_{240}P_{45}K_{180}S_{45}$	0.6967a	0.1530a	1.1830a	0.2400abc	0.2067ab	0.0310a
$T_{17} = N_{240}P_{45}K_{180}S_{60}$	0.7300a	0.1480ab	1.2000a	0.2520ab	0.2198ab	0.0260ab
$T_{18} = N_0P_0K_0S_0$	0.0533h	0.1300c	0.2567i	0.2010c	0.1710b	0.0212b
CV (%)	7.57	5.20	7.00	5.26	5.42	6.24

Means in a column followed by same letter (s) are not significantly different at 5% level of significance by DMRT

Nitrogen uptake by plant

Nitrogen uptake was favoured by the application of different levels of nutrients (Fig.1). The maximum nitrogen uptake (163.30 kg/ha) was noted in T_{16} receiving 240 N: 45 P: 180 K: 45S kg/ha which was statistically similar to T_5 but superior to the rest of the treatments. Treatments T_3, T_4 and T_8 were statistically similar in recording nitrogen uptake and ranked second in position. This might be due to the application of different nutrients which led to increase nitrogen uptake by cabbage. The lowest nitrogen uptake (7.58 kg/ha) was noted in T_{18} (control) treatment.

Phosphorus uptake by plant

Treatment T_{16} receiving 240 N: 45 P: 180 K: 45S kg/ha recorded the highest phosphorus uptake (5.63 kg/ha) by cabbage (Fig. 2). The effect of this treatment was statistically similar to T_9 but superior to the rest of the treatments under study. Treatments T_4 and T_8 were statistically similar in recording phosphorus uptake and ranked second in position. The lowest phosphorus uptake (0.62 kg/ha) was noted in control treatment.

Potassium uptake by plant

Effects of different nutrients on potassium uptake by cabbage were significant (Fig. 1). The maximum potassium uptake (18.35 kg/ha) by cabbage was recorded in treatment T_{16} receiving 240N: 45 P: 180 K: 45 S kg/ha. The effect of this treatment was statistically similar to T_3, T_4, T_8 and T_{13} treatments but superior to the rest of treatments. The lowest potassium uptake (3.49 kg/ha) was noted in T_{18} treatment.

Sulphur uptake by plant

Sulphur uptake by cabbage was significantly affected by the application of different nutrients (Fig. 1). Sulphur uptake varied from 2.57 to 32.60 kg /ha and the maximum sulphur uptake (32.60 kg/ha) was recorded in T_{16} which was statistically similar to T_{17} and T_4 treatments but superior to the rest of the treatments. However, all the nutrients responded significantly better than control treatment. The lowest sulphur uptake (2.57 kg/ha) was found in control treatment (T_{18}).

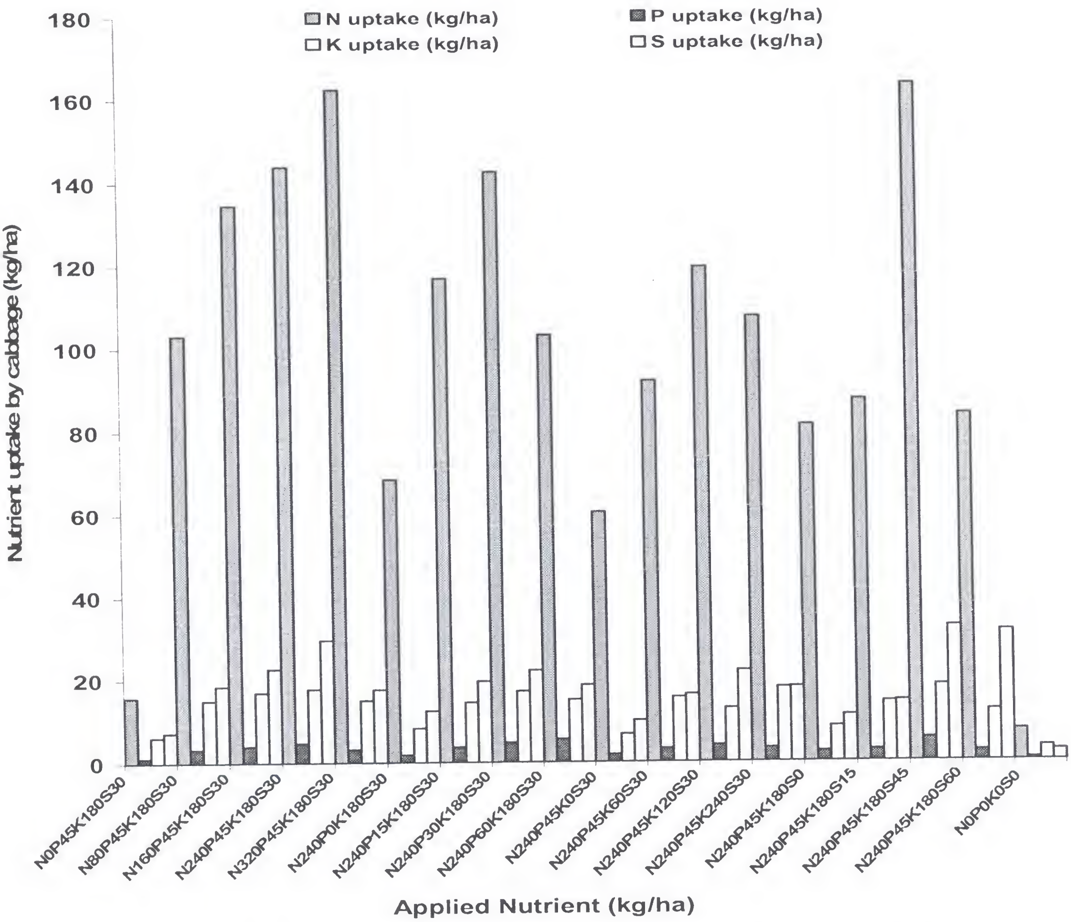

Fig. 1. Effects of different doses of nutrients on nitrogen, phosphorus, potassium and sulphur uptake by cabbage

Conclusion

Treatment receiving 240 N: 45 P: 180 K: 45 S kg/ha was the best in respect of different parameters of cabbage studied including plant height, leaf length, leaf breadth, thickness of head and Ca, Mg, S, Fe, Mn, Zn contents and N, P, K uptake by cabbage.

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Short Communication:

EFFECT OF GROWTH REGULATORS ON THE SUCCESS OF TRENCH LAYERING OF DIFFERENT GUAVA (*PSIDIUM GUAJAVA* L) VARIETIES

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Guava (*Psidium guajava* L) can be propagated by both seeds and vegetative means. But seed propagation is not generally practiced since it takes many years to come into bearing, normally do not produce true-to-type and often bear fruits of inferior quality. Propagation through vegetative way can improve the quality and production of guava. Vegetative propagation by layering has a good scope for those plants. But moisture stress and shortage of mother plants as well as limited number of branches restricts the production of air-layer in large quantity. Other methods of propagation like trench layering can be done in the soil condition when easy maintenance of moisture level in the root zone is possible. Besides within the short period large number of propagules can be produced per unit area. Use of growth regulators accelerate profuse rooting and can save the plants from storm. Patel *et al.* (1996) observed that IAA + IBA promoted percentage of rooting, number of roots, length of roots, survival percentage of layers and shoot growth. IBA alone was better than IAA alone. So, the present experiment has been designed to investigate the different concentrations of growth regulators of guava trench layering on their survivability and growth performance.

The present study was carried out at Fruit Research Station, Binodpur, Rajshahi during May 2004 to May 2006. Treatments are shown in Table 1. In case of trench layering, mother layers were collected from air-layering which was done in the month of May, 2004. Layers collected through air-layering were planted at 90° angle maintaining a spacing of 90 cm × 70 cm in the month of July, 2004. After establishment (about one year), the mother layers were laid down on the ground at the bottom of the trench and fixed with the help of wire hook in the month of May, 2005.

The laid layers were covered with rooting media (Soil+ well decomposed cowdung). After 15-20 days a large number of shoots were developed from the each node of the mother plant. When the bark of the shoot was reddish in color then layering was done at the base of the shoot by removing 4 cm long bark cylindrically and then scrapped exposing wood to remove the cambium layer from them with the help of a knife. Different concentrations of growth regulators in the form of paste were applied on the upper cut end of the exposed shoot. In case of control treatment, the same procedure was followed except that no use of growth regulators. The treated wood was then covered with the mixture of soil, well decomposed cowdung, sawdust and coconut coir. Root was formed about nineteen to twenty days after operation.

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After root formation the rooted layers were separated from the mother plant after 75 days (July, 2005) from the date of operation. Moderate pruning was done to the separated layers to check water loss from them through transpiration. Then the layers were planted in polybags and placed in a shady place and watering was done according to the need.

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The collected data on different parameters were statistically analysed and the means were compared by LSD test.

The effect of different guava variety and concentration of growth regulators showed significant effect on the percentage of success in rooting. Maximum success (100%) was obtained from the treatment combination V_1IBA_{1200} and minimum success (66.7%) was from V_3 x control (Table 1). This result was partially supported by Patel *et al.* (1996), who found the highest percentage of success in rooting when the layers Highest percentage (100%) of survivability was found from BARIGuava-1 with IBA $_{1200}$ and similar to 500, 800, NAA 500,800,1200, IAA 800,1200 and IBA 800,1200 where BARIGuava-2 with IBA 800, 1200, NAA 800,1200, IAA1200 and Kashi with IBA 1200. Bhagat *et al.* (1999) found that 88% survivability when the layers were treated with 3000 ppm IBA. The lowest percentage (76.4%) of survivability was obtained from Kashi and control treatment.

Combined effect of variety and concentration of growth regulators was significant in respect of number of roots per layer. Maximum number (53.0) of roots per layer was recorded from the treatment combination V_1IBA_{1200} (Table 1). This result is partially supported by Swingle *et al.* (1924) and Thimann (1935) who reported that IBA and NAA were found to be the most effective compound in stimulating adventitious root initiation. Maximum number (10.0) of roots was found from V_3x control (Table 1).

Combined effect of variety and growth regulators was highly significant in respect of length of roots per layer. The maximum root (17.0 cm) was obtained from the treatment combination V_1IBA_{1200} which was statistically similar to V_2IBA_{1200}. while shortest (9.2 cm) length from the treatment combination of V_3x control (Table 1). In case of trench layering all varieties showed better performance than air layering and mound layering. Significant variation was noticed in fresh weight of roots per layer due to the combined effect of variety and growth regulators. Maximum (28.5 g) fresh weight was obtained from the treatment combination V_1 IBA_{1200} while minimum fresh weight (7.5 g) from the treatment combination V_3 x control. Variation in the fresh weight of roots in different variety of guava was due to the variation of number and length of roots. Combined effect of variety and concentration of growth regulators significantly affected by the dry weight of roots per layer. Maximum (16.6 g) dry weight showed from the treatment combination V_1IBA_{1200} while minimum (4.0 g) from V_3 x control treatment combination (Table 1). Highest number (50.0) of shoots per layer was found from V_1IBA_{1200} treatment combination while lower number (14.0) of shoots per layer from V_3 x control treatment at different days. Highest number (243.3) of leaves was observed from the treatment combination V_1IBA_{1200} and minimum number (84.0) of leaves was found from the treatment combination V_3x control. This result is supported by Bhagat *et al.* (1999) who found the highest number of leaves when the layers were treated with 2500 ppm IBA.

Conclusion

The results of the study revealed that the use of growth regulators had significant effect on the rooting success and survivability of guava. It can be concluded that the guava variety BARIGuava-1 with growth regulator, IBA 1200 ppm showed the best performance incase in rooting of trench layering.

Table 1. Effect of growth regulators on the growth and success of different varieties guava in trench layering

Treat-ments	Success in rooting (%)	Percentage of Survivability (%)	No. of roots/layer	Length of root/layer (cm)	Fresh weight of roots/layer (g)	Dry weight of roots/layer (g)
V_1x Control	72.0	84.0	15	10.2	9.8	6.1
V_1IBA_{300}	85.8	97.1	26	13.6	15.0	7.3
V_1IBA_{500}	94.0	100.0	33	14.3	16.8	9.0
V_1IBA_{800}	96.0	100.0	41	15.6	21.0	11.1
V_1IBA_{1200}	100.0	100.0	53	17.0	28.5	16.6
V_1NAA_{300}	83.3	94.0	24	12.5	15.6	7.0
V_1NAA_{500}	93.0	100.0	30	13.7	16.0	8.2
V_1NAA_{800}	95.0	100.0	38	15.5	20.3	11.0
V_1NAA_{1200}	98.0	100.0	50	16.2	28.0	16.0
V_1IAA_{300}	80.0	93.0	21	11.0	13.9	6.8
V_1IAA_{500}	91.3	99.0	28	13.6	15.3	8.0
V_1IAA_{800}	94.0	100.0	35	14.0	19.6	10.0
V_1IAA_{1200}	97.5	100.0	47	15.8	26.5	15.2
V_2x Control	70.0	83.0	13	9.8	8.7	5.3
V_2IBA_{300}	82.0	94.3	24	13.0	14.6	7.0
V_2IBA_{500}	93.1	99.3	30	14.2	16.6	8.5
V_2IBA_{800}	95.0	100.0	38	15.0	20.0	10.1
V_2IBA_{1200}	98.2	100.0	51	16.4	28.0	16.0
V_2NAA_{300}	80.0	91.2	22	12.2	13.9	6.8
V_2NAA_{500}	91.2	98.7	28	13.4	15.1	8.0
V_2NAA_{800}	93.0	100.0	35	14.9	19.5	9.2
V_2NAA_{1200}	96.4	100.0	47	15.4	27.0	15.4
V_2IAA_{300}	78.0	90.4	20	11.2	13.0	6.1
V_2IAA_{500}	87.0	96.8	26	13.1	15.0	7.3
V_2IAA_{800}	92.0	99.0	33	13.3	18.3	9.0
V_2IAA_{1200}	95.4	100.0	45	15.2	24.1	15.0
V_3x Control	66.7	76.4	10	9.2	7.5	4.0
V_3IBA_{300}	78.0	90.0	20	12.4	13.2	6.0
V_3IBA_{500}	88.9	96.2	25	13.8	15.0	7.6
V_3IBA_{800}	91.0	97.0	32	14.2	18.0	9.0
V_3IBA_{1200}	96.9	100.0	45	15.9	26.0	14.1
V_3NAA_{300}	75.0	89.9	18	12.0	12.0	5.8
V_3NAA_{500}	86.0	94.5	24	13.1	14.0	7.0
V_3NAA_{800}	89.0	96.0	30	14.3	17.6	8.7
V_3NAA_{1200}	95.4	99.3	42	15.1	25.3	13.6
V_3IAA_{300}	71.0	87.0	16	10.6	11.05	6.03
V_3IAA_{500}	83.2	91.4	21	11.5	13.45	6.20
V_3IAA_{800}	87.8	93.0	28	13.1	16.20	8.02
V_3IAA_{1200}	91.9	98.0	37	15.0	24.00	12.05
$LSD_{(0.05)}$	1.49	1.57	2.44	0.84	1.29	1.41
CV (%)	1.04	1.01	4.87	3.80	4.47	9.29

V_1 = BARIGuava-1, V_2 = BARIGuava-2 and V_3 = Kashi

Table 2. Effect of growth regulators on the number of shoot and leaf of guava trench layering at different days after planting (DAP)

Treatments	Number of shoot at				Number of leaf at			
	25 DAP	100 DAP	175 DAP	280 DAP	25 DAP	100 DAP	175 DAP	280 DAP
V_1x Control	7.0	12.0	15.0	19.0	27.3	51.0	69.0	102.0
V_1IBA_{300}	10.0	16.0	20.3	24.3	39.0	79.0	100.3	147.3
V_1IBA_{500}	13.3	19.3	22.0	25.3	41.3	95.0	118.3	168.0
V_1IBA_{800}	14.0	21.0	25.3	29.3	47.0	102.0	121.0	183.0
V_1IBA_{1200}	20.0	30.0	43.0	50.0	71.0	114.3	155.0	243.3
V_1NAA_{300}	9.0	14.0	17.0	22.0	37.0	67.3	87.0	124.0
V_1NAA_{500}	10.3	17.0	19.0	23.3	41.0	87.0	110.0	144.0
V_1NAA_{800}	12.3	18.0	23.0	27.0	46.0	93.0	114.3	152.3
V_1NAA_{1200}	18.0	27.0	33.0	39.0	56.0	105.3	135.0	205.3
V_1IAA_{300}	8.0	12.0	15.0	19.0	35.0	63.0	84.0	122.0
V_1IAA_{500}	9.0	15.0	17.0	22.3	40.6	72.0	96.0	132.0
V_1IAA_{800}	10.3	16.0	20.0	26.3	40.3	82.3	105.3	146.0
V_1IAA_{1200}	15.3	24.0	26.0	30.0	51.0	103.0	125.0	188.0
V_2x Control	5.0	10.0	12.0	17.0	23.0	42.0	59.0	86.0
V_2IBA_{300}	7.0	12.0	15.0	20.3	34.3	54.0	72.3	110.3
V_2IBA_{500}	10.0	14.0	18.3	22.0	40.3	64.3	86.0	134.0
V_2IBA_{800}	11.3	16.0	19.0	24.0	42.0	75.0	106.0	163.0
V_2IBA_{1200}	16.0	23.0	31.0	39.0	56.3	94.0	133.0	208.0
V_2NAA_{300}	7.0	11.0	14.0	19.0	32.0	47.0	67.0	104.0
V_2NAA_{500}	8.0	14.0	16.0	20.0	35.3	55.3	79.0	117.0
V_2NAA_{800}	9.3	15.0	20.0	24.0	39.6	67.0	96.0	179.3
V_2NAA_{1200}	13.6	17.3	22.0	30.3	53.0	84.0	116.3	210.6
V_2IAA_{300}	6.0	9.0	12.0	17.0	29.0	44.0	61.0	92.0
V_2IAA_{500}	7.0	12.0	14.0	19.0	33.0	51.0	73.0	109.0
V_2IAA_{800}	8.0	13.3	17.0	23.0	34.0	59.3	86.0	131.0
V_2IAA_{1200}	12.3	16.0	20.3	25.0	50.0	78.3	106.3	167.0
V_3x Control	4.0	7.0	9.0	14.0	21.0	40.0	57.0	84.0
V_3IBA_{300}	6.3	11.0	14.0	18.0	32.0	51.0	70.3	108.0
V_3IBA_{500}	8.0	13.0	16.3	19.0	37.0	61.3	84.0	132.0
V_3IBA_{800}	9.0	14.0	17.3	23.0	39.0	73.0	102.0	159.3
V_3IBA_{1200}	12.3	18.3	23.0	29.0	49.3	89.0	128.3	202.0
V_3NAA_{300}	5.0	8.0	11.0	16.0	31.0	45.0	65.0	102.0
V_3NAA_{500}	7.0	11.0	13.0	17.3	34.0	53.0	77.3	115.3
V_3NAA_{800}	8.0	12.0	17.0	21.3	38.0	65.0	93.0	140.0
V_3NAA_{1200}	10.3	16.3	20.0	26.3	48.0	79.0	111.0	173.0
V_3IAA_{300}	5.0	6.0	10.0	14.0	29.3	42.3	59.3	63.0
V_3IAA_{500}	6.0	9.0	11.0	16.0	34.0	49.0	71.0	107.0
V_3IAA_{800}	7.3	10.0	14.0	20.0	37.0	56.0	84.0	129.0
V_3IAA_{1200}	9.0	15.0	18.0	24.3	45.0	73.3	103.3	162.0
$LSD_{(0.05)}$	1.50	2.35	2.15	2.35	2.56	1.99	2.29	25.29
CV (%)	9.59	9.81	7.17	6.16	3.97	1.77	1.50	10.94

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